VAN NOSTRAND'S
ECLECTIC
ENGINEERING MAGAZINE.

NO. XXXV.—NOVEMBER, 1871.—VOL. V.

THE METRIC SYSTEM.*

I.

GENTLEMEN OF THE CONVOCATION: The sense of the right of property is an instinctive feeling, of which the existence is co-extensive with intelligence. We find abundant evidence of its presence in the lower animals as well as in ourselves. The dog, for instance, when he has satisfied his hunger, carefully stores up the superfluous bone of to day in prudent provision for the anticipated wants of the morrow. The beast of the forest bears his prey to the lair which he has appropriated to himself, and the birds defend with spirit the nests which their own labors have constructed. In the social animals, as the beaver, and the social insects, as the ant and the bee, we see the principle more broadly developed. In these cases, the dwelling which the common toil has constructed or prepared, and the stores which the common industry has gathered, are the common property of all, and are apportioned for the benefit of individuals upon principles which we probably do not understand. But the lower animals, though they appropriate to themselves articles which seem desirable, and assert a right of property in the objects thus appropriated, never propose to relinquish one possession in consideration of an equivalent offered in the form of another. They have no notion of commerce or exchange even in its simplest form. The commercial idea makes its first appearance in man. It is present in every stage of human civilization. Its earliest practical illustration is in the form of barter, in which objects supposed to have value are exchanged one against the other, or a single one of a certain description for several of another. But as wealth increases, and its forms become more diversified, the necessity of determining equivalents by quantity rather than by tale, becomes manifest; and out of this necessity springs the creation of conventional standards, by means of which quantities may be always and everywhere verified and definite quantities be correctly ascertained. Hence have arisen the various systems of weight and measure which have prevailed among different peoples, some form of which has been found to accompany even the rudest civilization. Such systems, having originated before anything like intellectual culture existed, have been constructed without any thought of scientific method, and have owed their earliest form to accident or caprice. As social and political institutions have become more fully developed, legislation has stepped in from time to time to alter, if not to improve, these primitive systems; to change the value of their unit bases, or to modify the relations to these bases of the derivative denominations; until, at the present time, there is no reason to believe that there survives in any existing system of weights and measures a single value of

* A paper read before the University Convocation of the State of New York. By FREDERICK A. P. BARNARD, D. D., LL. D., President of Columbia College.

any unit identical with one in use two thousand years ago; or a law of derivation connecting the different branches of the system, the weights and the measures of capacity, for instance, with the linear base, such as governed the same relations at a period so far remote in the past as the earlier ages of the Christian era.

To change systems of weight and measure, and to change them by legislation, is therefore no new thing, first thought of in our day. It is a thing which has been going on ever since the birth of civilization. It is not in itself a good thing or a desirable thing, or a thing we should engage in for its own sake; neither is it a desirable thing to pull down a dwelling in which we have long lived, even though it may be inconvenient. Time has, perhaps, reconciled us to the inconveniences; use has made us forgetful of their existence, or habit has possibly, for such is human nature, converted defects into merits in our eyes. But when we do pull down the old home, and we often do, and Americans do so probably oftener than they ought, and in its place erect an edifice constructed on better principles, we find, in the increased comfort which follows, a justification of the proceeding, and an adequate compensation for all the trouble and expense it has cost us.

There has grown up within our own century a branch of systematic inquiry, which in recent years has been prosecuted with a high degree of activity, under the name of social science. This inquiry comprehends in its scope every problem interesting to human society, political, educational, moral, economical, commercial, statistical, and sanitary: its aim being not merely the enlargement of knowledge for its own sake, but the practical amelioration of the condition of man. In an investigation so comprehensive, the subject of weights, measures, and coins, the instruments by means of which the values of all objects which make up the wealth of nations must be measured, and by means of which also the exchanges of commodities which constitute the world's commerce must be effected, could not escape attention. An earnest movement has accordingly been going on in our time, which, during the past twenty years, has been pressed with especial urgency, having for its object to remove the impediments to freedom and facility of commercial intercourse between nations, and the obstacles to the intelligent understanding on the part of individuals, of the material condition of the world and the progress of contemporaneous history, which arise from the diversity and discordance of existing metrological systems. At a former meeting of this convocation, an ardent friend of the movement here spoken of, a gentleman who was at that time a member of our national legislature, addressed you on this subject, and recommended it earnestly to your favorable consideration. The result was disappointing. The movement failed to command from you the anticipated sympathy; and in approaching the same subject to-day, I feel how heavy is the task of one who attempts to plead before you a cause in which so able, so zealous, and so eloquent an advocate has failed.

There is something in the very fact that I venture to address you upon a subject which has occupied the attention of your learned body now for several years, which has been regularly referred to a committee of able and distinguished men selected from your number, which has been maturely considered and elaborately reported on by them, and has, at length, after full opportunity for discussion and comparison of views, been finally disposed of by the adoption and publication of their report, which convicts me, in appearance at least, of presumption, and which is not likely to win me your favor in advance. It is, therefore, due to myself to say, that in asking your indulgence while I recall your attention for a few moments to a subject which has lost its novelty for you, I am acting under instructions from a body whose authority I am not at liberty to disregard. On the first day of May, last, a resolution was adopted by the board of trustees of Columbia College, in the following words:

"*Resolved*, That the President be requested to attend the next meeting of the Convocation of the University of the State of New York, and to explain to that body how far the views of the Faculty of Columbia College, in respect to the Metric System of Weights and Measures, are in accordance with those set forth in the report of a committee made to the Convocation on that subject in August last."

This resolution imposes upon me a duty which I have no choice but to fulfil. I

trust, therefore, that I shall not be suspected of intending any disrespect to the Convocation if, in discharging it, I give expression to views considerably at variance with those which have received the sanction of this body.

The interest of the trustees of Columbia College in the Metric System of Weights and Measures, dates back to a period preceding my own connection with that institution. In the minutes of the Faculty of the college, I find it stated, under date of April 8, 1864, that a resolution calling the attention of the Faculty to the subject, had been passed by the trustees on the Monday preceding; and this resolution is recorded under a date a little later, in the following words, viz.:

"*Resolved*, That in view of the important international movement in progress for the purpose of establishing a uniform system of Weights, Measures, and Coins for the civilized world, it be referred to the Faculty of the College to prepare and submit to this board a memorial to the Congress of the United States, on behalf of the college, expressing its sense on the importance of the measure in question."

In compliance with the request of this resolution, a committee was appointed to draw up such a memorial, consisting of Professors McVickar, Anthon, Davies, Lieber, and Rood. Upon the 13th of May next following this appointment, the committee reported a memorial which was adopted by the board of the college, and ordered to be signed by the president and laid before the trustees.

In this memorial, the metric unit of length is compared with the British (and American) unit; and the metric system of derivation, by which the measures of surface, capacity, solidity and weight, are deduced from the unit of length, is compared with the confused system, or lack of system, which unfortunately pervades the metrology of the English-speaking nations; and on both these points the opinion of the Faculty of Columbia College is expressed, with an emphasis which argues deep conviction in favor of the former. The memorial goes further, and advocates certain views in regard to the unification of the coinage of the world, in which I should not be able fully to concur, but to which I design to give no present attention, since the coinage question is one which will probably be independently settled; though, when it is settled, it will doubtless be settled by making the weights of all coins metrical.

In the minutes of the trustees of the college, I find it recorded that the document here spoken of was read before that body on the 18th of May, 1864, and that an order was afterwards taken, directing that it should be forwarded to the Speaker of the House of Representatives at Washington, with a request that he should lay it before the national legislature. This memorial is spread at length upon the minutes, both of the faculty and of the trustees. Along with it appears, in the latter, an independent memorial, expressing similar sentiments, which was adopted by the trustees in their own behalf, and forwarded to Congress, by their order, at the same time.

With all this history I had nothing to do. The whole transaction had been completed before I became a member either of the Faculty or of the Board of Trustees of Columbia College. I have recounted the particulars in evidence that Columbia College had taken her position on this question long ago. The duty imposed upon me is to state to you some of the reasons which have led her to assume this attitude.

And here I wish to be understood as not intending to assert that, among the members of the two bodies whom I, in a certain sense, represent here, there are not individuals who dissent from the views to which the majority have committed themselves. Among the trustees, indeed I know of none such; but your own records show that there is at least one distinguished dissentient among the Faculty. If there are others, they, as well as myself, are members of this convocation; and they may, and perhaps will speak for themselves. I am not aware that there are any, but my impression may be mistaken.

To proceed now to the matter in hand, it is, in the first place, a fact particularly noteworthy that the trustees of Columbia College, in their resolution of April, 1864, did not mention the metric system in so many words, nor propose to memorialize Congress in favor of any particular system of weights and measures designated by name. What they asked was, that the college should express its sense of the importance of the creation of a *uniform*

system of weights and measures for the use of the civilized world. If they have been led to believe, as I think they have, that such a uniform system can be reached in no other way than through the ultimate adoption of the metric system; and that whatever may be the differences of opinion as to this matter just here and now, such a result most inevitably will be reached in this way sooner or later, it is impossible that they can regard without concern the exertion of any influence which may serve sensibly to retard an event deemed by them so desirable, and which, however retarded, is, in their opinion, sure to come at last.

But still the question raised by them, and the question first in order before us now, is not, whether it is expedient that we should forthwith adopt the metric system; it is rather, whether it is worth while to try to secure a common system; because if this is not so, there is nothing left to talk about. Nor yet, supposing that this first question is settled affirmatively, and we agree that a common system of weights and measures would be worth having if we could get it, can we make the question of the metric system even the second question in order; for the second question should be, what are the efforts, of those which we are able and willing to make to secure the desired object, in attempting which we may be encouraged by the hope of success; and what are those which we may as well take warning in the outset to avoid, as certain inevitably to fail.

Now, in looking at the different metrological systems at present in use in the civilized world—and the number is very encouragingly smaller at present than it was even 20 years ago—we shall see that the great obstacle in the way of the practical unification of systems is not the mere fact of difference in the absolute magnitude of the standard units, whether of weight or of length or of surface or of capacity; nor the mere fact of difference in the names by which we distinguish these units and their multiples or subdivisions; nor the mere fact of difference in the arithmetical law by which the several denominations of weight or measure are related to each other; nor yet the greater or less degree of exactness with which the base of any system may conform to any dimension in nature, variable or invariable; though these are matters concerning which a great deal of breath is wasted in the discussions which go on about the metric system; the difficulty which stands out so prominently as to dwarf the rest to insignificance, is the fact that the standard units of these several systems are practically incommensurable— I say *practically* incommensurable, I am not using the term with strict scientific severity; but the difficulty is as serious as if the incommensurability were actual and absolute.

To illustrate what I mean, the Austrian foot measure, for instance, exceeds our own by 361 ten-thousandth parts; or, expressed in inches, is equal to 12 British or American inches and 4332.10000 of an inch. We might reverse the mode of presentation, and say that the American foot is 0.96516 of an Austrian foot, or 11.5819 Austrian inches. The fractions here given do not express the exact relation. We may run the decimals on for half a mile without reaching the end; but they go far enough for the purpose of my illustration.

To transform, therefore, a value expressed in one of these measures, into an equivalent value expressed in the other, is an operation laborious and irksome. But the arithmetical disadvantage is by no means the whole, or even the greater part of the evil which this state of things produces. A much more grave consideration is the fact that it interposes an effectual bar to the intelligent interchange of thought. It renders it impossible for an American to converse understandingly with an Austrian on any subject involving quantities of any description. It makes it impossible for an American to derive instruction from an Austrian book or magazine or journal where quantities are mentioned, or an Austrian from an American. This is an enormous evil, and as it exists not in this quarter only, but everywhere, the world has crying need of its removal. It is the evil of which, first and chiefest of all, the advocates of metrological reform desire to be rid. And yet unless I greatly misunderstand the purport of much of the reasoning I hear going on upon this subject, the very fact that this abominable evil exists, the very fact that there is something to be got rid of, and something that we want to be rid of, and something which we ought to be rid of, is

made an argument why we should not try to be rid of it at all. If there are any to whom this argument is satisfactory, with them, of course, the case is closed, and upon such, nothing that I can say will produce any impression. There are some, probably, not of this class, and they may be disposed to consider with me what means there are by which we may be relieved of this artificial obstruction to intelligent communication with other peoples. Three methods present themselves. Continuing the illustration furnished by the example just presented, they are these: We may adopt the Austrian unit; Austria may adopt ours; or both nations may adopt a third, incommensurable with either. Any one of these expedients will reconcile us with each other; that one will be chosen, if any, which, besides doing this, will do most to promote the grander object of an universal accord among nations.

Now, if we go over to Austria in this matter, we lose more than we gain; and in speaking of loss and gain here, I mean loss and gain as it respects our international relations, and not as it respects our internal or domestic affairs—(I am setting aside altogether, therefore, that inconvenience to ourselves at home, which would exist temporarily in consequence of the incommensurability of the new unit with the old—an inconvenience on which your able reporter has so feelingly dwelt as likely to result from our giving up the foot for the metre)—we lose then, I say, more than we gain by this concession, because we fall out of harmony with the great British Empire for the sake of securing harmony with a people who occupy, as Mr. Webster more forcibly than politely remarked, only a small patch of the earth's surface, compared with our vast domain. On the other hand, if Austria yields the point, she will fall into harmony, it is true, with us and with Great Britain—nations, however, with whom which she is geographically separated very widely; but this advantage will be gained at the expense of discord with the several peoples who lie between her and the British Islands; all of whom have embraced the metric system, or adopted metric values in their own. If, however, thirdly, both of us adopt the metre, America will not only be in accord with Austria but with the greater part of continental Europe at the same time; and as Great Britain has given decisive indications of a disposition to become metric also, the probability is that soon the whole civilized world, unless Russia and the Scandinavian people continue to be exceptions, will have but a single system of weights and measures.

Now if this difference between us and Austria had not been *such* a difference; if the unit, for instance, of Austria had been we will say a cubit, and such a cubit (for there have been many of them) as to be exactly equal to 18 British in., the evil of incommensurability would not exist and the question of unification would simplify itself materially. We might both of us agree to adopt a measure of 6 in. as our common unit, and this we might call a span, abandoning both the cubit and the foot. There would be some no doubt who would lament over the loss of the "short and sharp Saxon word, foot," and would find no sufficient comfort even in "span," which, though Saxon and short, is not so sharp; but I think that if a change of this simple description, affecting only names and modes of division, and not actual values at all, would bring us into harmony with any great people, and still more if it would bring us into harmony with all the world, we should do it notwithstanding. This illustrates the immense difference as it respects facility of solution which the problem of metrological unification would present, if the unit bases of the existing national systems were commensurable, as compared with what it is now.

With the great empire of Russia, we have, indeed, precisely such a point of contact in our two national systems of length measure as that which I have just been imagining. It is matter of familiar history, that in the year 1698 the singularly enterprising and energetic Emperor, Peter the Great, passed, incognito, in the train of one of his own embassies, first into Holland, where he engaged himself as an operative ship-carpenter, and labored for months with remarkable assiduity; and secondly, in the following year, into England, where he became finally, master of that important branch of constructive art; and where subsequently having made himself known to the then reigning king, William III., he received from him every honor due to his exalted station. Returning to his own country, he took with him a number of British ship-builders and other artificers, whom he paid with liber-

ality and employed in the navy-yards which he immediately proceeded to found. It was probably a consequence of his own industrial education in England, and of the British predilections of the advisers and practical assistants whom he took home with him to carry out his plans, that he was induced to modify the length of the *sagene*, the standard length unit of the empire, so as to make it commensurable with the British foot. Since early in the 18th century, therefore, the length of the legal standard unit of Russia has been 7 ft., subdivided into 3 archines of 28 in. each; the archine being the unit of common life, just as in England, the yard is the legal, and the foot the practical standard. This state of things admitted of the introduction between ourselves and Russia of a common unit of 4 in. in length, which would have been just the seventh part of an archine and the third part of a foot. But within the last forty years a simpler solution has been found, the Russian government having introduced a subsidiary unit, having the length of $\frac{1}{7}$ of a sagene, and which is called by a name approaching as nearly to the English word foot as the vocal organs of the people will allow.

It is unfortunate that a reform so well begun was prosecuted no further. This is the only particular in which the Russian metrological system has anything in common with ours, or with any other existing. And, from a careful examination of all the systems of weights and measures established by law, and at present in use among civilized peoples, I have been unable, except in this single instance, to discover between any two of them any feature of commensurability, whether as it respects weights or measures of length or surface or volume, which has not been introduced by legislation since this century began. Such legislation, however, has done so much toward removing this chief of all obstacles to the attainment of a common system, as to greatly encourage the friends of metrological reform in the hope of an ultimate and complete attainment of the object in which they are so deeply interested. It is worth remarking, furthermore, that every such change has thus far consisted in replacing the values of the weights and measures in common use by other values adopted from the metric system. I will enumerate further on the most important of these changes; pausing here only to present a single example to show how, in some instances, the great evil of incommensurability has been got rid of without the adoption of the metric system in all its details.

In the republic of Switzerland, previously to the year 1851, there prevailed a considerable diversity of systems of weight and measure in the different cantons. The most important may be said to have been those of Berne, Zurich, Basel and Lucerne—I will confine myself to the two first named. In Berne, the fuss (unit of length) was 11.546 in.; in Zurich, it was 11.812 in. In Berne, the pfund (unit of weight) was 18.642 oz. avoirdupois; in Zurich, it was 18.347 oz. In Berne, the maas (measure of liquid capacity) was 1.776 quarts; in Zurich it was 1.918 quarts. The measures of dry capacity were very various, but those which are most easily comparable were the mass, in Berne, which was 0.3876 of a bushel, equal to 1.550 pecks; and the viertel in Zurich, which was 0.5826 of a bushel, or 2.330 pecks. Zurich had, in fact, four different viertels for different substances; the measure given above was for wheat. By a law passed the 23d of March, 1851, it was decreed that, after the 31st of December, 1856, the legal unit of length throughout the republic should be the pied (foot), having the length of exactly 30 centimetres, and that (abandoning the old duodecimal subdivision) this should be decimally divided to tenths, hundredths and thousandths. Multiples of the unit allowed were the brache, 2 ft.; the aune, 4 ft.; the toise, 6 ft.; the perche, 10 ft., and the lieue, 16,000. For the pfund was substituted the livre of 500 grammes, and for subdivision it was left optional to use the binary system of $\frac{1}{2}$ lb. and $\frac{1}{4}$ lb., and so on, or to employ the decimal. For dry capacity, the measure established was the quarteron, equal to 15 litres; and for liquid capacity, the pot, equal to $1\frac{1}{2}$ litres. For the last fifteen years, therefore, the weights and measures of Switzerland have been commensurable with those of the neighbors with whom she is in most frequent intercourse, and who have all of them more or less completely adopted the metric system.

But though the incommensurability of the unit bases is the principal source of difficulty in effecting the transformations of value from one metrological system to another, the law of derivation of the other

denominations from these bases is not a matter of indifference as it respects this operation. This again can be illustrated by an example which the commensurability of the Russian standard unit of length with our own enables us to derive from the itinerary measure in common use in the Russian Empire. The itinerary unit is the viesta, Anglicized verst, which is equal to 500 sagenes. Now, there is no difficulty in converting versts into British feet, since, the sagene containing 7 ft., 500 sagenes are 3,500 British ft., or the half of 7,000 British ft.; so that we only have to multiply the versts by 7, annex 3 zeros, and take half the result. But if we wish to transform a distance expressed in versts into miles—a mile being the unit of our own itinerary measure—the process is not so simple. There are 5,280 ft. in a mile, and if, in order to avoid this troublesome divisor, we attempt a reduction through the intermediate denominations, we encounter such relations as $5\frac{1}{2}$ yards, or $16\frac{1}{2}$ ft., making a rod, which are more troublesome still. Now if, instead of the present totally indefensible series of relations between our higher and lower denominations of length, we had something a little more sensible, or if not sensible, at least not worse than the Russian—for the Russian, with its ratio of 7 to 1, is only a little less bad than ours—the problem before us would admit of a solution comparatively simple. Suppose, for example, that a mile were made, as it might be, without harm to anybody, a round 5,000 ft. It is true that "the old familiar mile of 1,760 paces," which your reporter seems to cherish so fondly, "would be gone; and," as he correctly remarks, "the distance from Albany to New York—145 miles—would be known to us" as something quite different, say something like 153 sensible miles. In this case the verst would be 3,500-5,000, or $\frac{7}{10}$ of a mile, and the transformation would be effected by the use of a very small number of figures. It would not, perhaps be worth while to adopt the new value of the mile here suggested, for the sake of being able merely to convert miles to versts, or versts to miles—a thing we have to do too seldom to make it a matter of much interest to us; but it would be quite worth while to make it for the sake of facilitating the thousand other calculations which we are continually called upon to make, involving reductions between the higher denominations of length and the lower. Whether we ever adopt a new linear base for our metrological system or not, every consideration, both of logic and of convenience, demands that we should reform the absurd numerical relations in which our different denominations, especially of length, surface, and capacity, stand to each other. Mention has been made of the mile, the rod, the yard, and the foot. Along with these we may take also the chain of 66 ft., divided into links of which each one is $7\frac{92}{100}$ in., while itself is the eightieth part of a mile. As to surface, our sq. yard is 9 sq.f t.; our sq. rod is $30\frac{1}{4}$ sq. yards, or $272\frac{1}{4}$ sq. ft.; and the acre, our agrarian unit is 160 sq. rods, or 4,840 sq. yards, or 43,560 sq. ft. It would be difficult for human ingenuity to contrive anything more inconvenient or less rational than this. As to capacity, whether liquid or dry, though the relations of the several denominations to each other are tolerably simple, yet their relations to the standard of length, which is, or ought to be, the fundamental base of the system, are as abnormal as it is possible to make them. Our gallon is 231 cubic in., 0.13368 of a cubic ft.; and our bushel is 2,150.42 cubic in., 1.244456 cubic ft. And our unit of weight has no relation whatever expressible in simple numbers, which the mind can grasp, to our measures of capacity or of length; for while it is customary to say that a cubic foot of water weighs 1,000 ounces, the relation established 40 years ago by our bureau of weights and measures under authority of law, makes the gallon measure of distilled water at the temperature of 39.8 deg. F., and at 30 in. of the barometer, to weigh 58,372.-1754 grains, or 8.3389 commercial or avoirdupois lbs.; and requires also that the standard or Winchester bushel of 2,150.42 cubic in. shall hold, under the same circumstances, 543,391.89 grains, or 77.6274 avoirdupois lbs.; from either or both which determinations it appears that the weight of a cubic foot of water, at maximum density, is only 998.0667 oz., instead of 1,000 oz.; while, if we take the water at the ordinary temperature of the atmosphere, say 62 deg. F., as prescribed by the British statute on the subject, the cubic foot weighs but 997.172 oz. Here are irregularities and imperfections, to the correction of

which it would be well if we would address ourselves, in our own immediate interest and that of our people at home merely, and without reference to our relations with other peoples. Exact calculations, for instance, in which weights are to be deduced from volumes or volumes from weights, are effected under our system only at the expense of much weary labor, of which the necessity is artificially laid upon us by this tyranny to which we are born. For rude calculations we call, indeed, the cubic foot of standard water 1,000 oz., or 62½ lbs.; but for any delicate determination, we must take the cubic foot at 436,654 2 grains, and the cubic inch at 252.6934 grains, numbers which, at whatever inconvenience, the man of science finds himself continually obliged to employ in multiplication and division, to the great waste of his time and expense of his strength.

Now, before directly considering the special question whether the metric system of weights and measures ought to be adopted in this country, it is proper to consider, and it seems to me a duty to consider whether it is possible for us to contribute anything to the important object of bringing the bases of the metrological systems of the world into relations of commensurability. If these bases can be made commensurable, we shall have accomplished something almost as important as to have established absolute identity; and, indeed, under these circumstances, identity, it may easily be believed, will not be slow to follow. Who can doubt, for instance, that Switzerland, having adopted values for her units which are in extremely simple relations to the metric units, will sooner or later adopt the metric units themselves. It is what all the States of North Germany recently resolved to do after an experience very similar. These several States had all, previously to the formation of the Zollverein, their independent systems of weights and measures. When that treaty was entered into, the importance of a common system for custom-house purposes was promptly perceived; and hence a Zollverein pound was adopted, having the weight of 500 grammes. Several of these States, among them Prussia, Baden, Hesse-Darmstadt and Wurtemberg, found it expedient at a later period to adopt this weight for their domestic as well as for their external commerce. And after the Austro-Prussian war of 1866, and the formation of a closer union between the States north of the Maine under the name of the North German Confederation, the desirability of a common metrological system for all the members of the Confederation seemed so great, that a law was finally passed by the Reichstag which was publicly proclaimed by the king in August, 1868, by which the metric system is adopted in full, and made the legal system for North Germany from and after January 1, 1872. As the States of Southern Germany were no less advanced than those of Northern, in the measures they had taken previously to their absorption into the empire, for the assimilation of their weights and measures to those of the metric system, there can be no doubt that the law of 1868, just mentioned, will be extended over them also. Thus it appears that when different metrological systems approach each other so far as to become commensurable in their fundamental units, there is a drift towards identity which becomes at length irresistible.

Are we willing to do anything to bring our own system into relations of commensurability with those of the rest of the world? If so, the question second in order comes up, what efforts are there in our power to make, which are likely to advance the object, and what are likely to be fruitless? It may be well to state, in the very outset, so as to bring the really vital question directly before us, that except the metric system and that which we use ourselves, no other existing, and no other likely to exist, can be advocated as having the least claim to become the system of the world. One of these, therefore, must sooner or later prevail; for no man not totally regardless of the history of the past, and not absolutely blind to what is taking place under his own eyes in the present, can possibly pretend to believe that the world is to be for ever without a uniform system of weights and measures. At the universal exposition of 1867, in Paris, 13 measures of length from different countries were exhibited under the name of foot, or its equivalent; but among these there were only 8 values essentially different, and 2 of these were metric. Yet after giving some attention to this subject without pretending to ex-

haust it, I have found more than 100 foot measures, each differing more or less from all the rest in value, which have been in use at one time or another at one part or another of Europe. Similar remarks might be made of the units of weight and capacity. There has, therefore, been large progress made toward uniformity, and the most important steps and the most significant steps are those which have been taken within our own century. We cannot suppose that this progress is going to be arrested at the point which it has now reached. Of the two systems therefore just now indicated as the systems between which the world must choose, unless in regard to this matter it shall henceforth stand still for ever, one or the other must sooner or later prevail. Which shall it be? Which is it likely to be?

At the close of the last century the metric system was thrust upon France, under circumstances of disadvantage and with an imperfect success, which Mr. Adams has very eloquently described in his able report of 1821, which you have caused to be reprinted. Though the commission by which the system was matured was as far international as it was possible in the then existing political and military condition of Europe to make it, representatives being present not only from France but also from the Netherlands, Denmark, Sweden, Spain, Switzerland, Sardinia, Rome and other Italian States, yet no government except the French spontaneously adopted and endeavored to apply in practice, the results of their labors. The conquests of the first empire carried the system forcibly into the low countries, into Westphalia, into Italy and into the Iberian peninsula; but the difficulties which it met with there were in general greater than at home; not only because the manner of its introduction did violence to men's established habits of thought, but because its existence was a badge of subjugation and a perpetual reminder of the national humiliation of those who were compelled to use it. These all with one accord, therefore, took advantage of the downfall of the empire, to throw it promptly off. Nor even in France, presented as it was to the people without any adequate education as to its characteristic features, or any sufficient allowance of time to permit them to become familiar with its details, was it established without a struggle against inveterate habits and rooted prejudices continued through more than a quarter of a century. Long before the termination of this struggle, however, the aversion to the system in the countries foreign to France, to which it had been carried during the empire, began sensibly to subside; and in the Netherlands, whose intimate relations with France had caused it there to take a deeper root than elsewhere, it was actually re-established as early as 1817. It was re-established, that is to say, in all particulars except the nomenclature; but while the metric units and the metric decimal relations were adopted, the ancient names of weights and measures were retained. But Belgium, since the separation, has adopted the nomenclature also; the old names are still preserved in Holland. The condition of things therefore, at the time when Mr. Adams wrote, may be thus described. A quarter of a century had passed, and yet the system was not yet firmly established in its own home; it had been rejected generally by the neighboring peoples who had tried it, and its chances of success in the eyes of the disinterested spectators of the experiment appeared, as may be gathered from Mr. Adams's own report, to be as nearly as possible at zero. Since that period just one-half a century has passed, and the aspect of things is bravely changed. One third part only of this period sufficed for the subsidence of all the imputed disaffection of France, and in the Netherlands, as we have seen, this disaffection, if it was ever strong, died out much earlier. From the year 1837 onward, the people of those two countries have not only been reconciled to the system, but warmly attached to it. The neighboring peoples upon whom it had been early imposed by force, and who had indignantly thrown it off, have all voluntarily re-adopted it. That early attempt to coerce them into its acceptance, while it roused every instinct of their natures to resistance, had at least the effect to educate them to a knowledge of what it was. And the acquaintance which they thus formed of its merits, produced, when passion had subsided, its natural result in the re-establishment of the system by their own free choice. From information obtained at the uni-

versal exposition of 1867, where a special pavilion was set apart for the display of the standards of weight, measure, and money of all nations, officially authenticated, I am able to state some particulars as to the progress of this great movement toward metrological uniformity. First in the order of time after France, Holland and Belgium, came the Italian States, which, beginning with Sardinia, by laws initiated in 1845, and carried into execution in the following year, made the metric system the only legal system of weights and measures in that peninsula. Not far from this time was formed the custom union, or zollverein which I have already mentioned, among the German States, including Prussia, Hanover, Saxony, Bavaria, Baden, Wurtemberg, the Hessian Duchies, and several smaller principalities and free cities. This was established for the purpose of doing away with the serious obstruction to commerce interposed by the existence of numerous and neighboring custom-house frontiers; but in order that it might not create as much trouble as it removed, it adopted, as I have mentioned already, a common system of weights and measures, giving metrical values to the units. The metric pound adopted was half a kilogramme, or 500 grammes; and this was found so convenient that it subsequently became the national as well as the international pound in several of the principal States and many of the smaller; as, for instance, in Prussia, Wurtemberg, Baden and the Hesse Darmstadt.

In some, as in Baden and Hesse-Darmstadt, metrical values were also given to the unit of length, which was still called the *fuss*, though the old *fuss* was abolished, and the duodecimal subdivision was at the same time abandoned. Others of these States, which still retained the values of the fuss to which they were accustomed, perceiving the great superiority, in respect to convenience, of the decimal over the duodecimal ratio, also abolished the inch and divided the foot into tenths and hundredths. Among these may be named Bavaria, Prussia and Wurtemberg. Very shortly after the revolutionary excitements of 1848, the empire of Austria, by treaty with Prussia, became connected with the Zollverein, and introduced the metrical weights and measures of that union into all the custom-houses of her extended frontier; nor has the course of events, military or polical, of recent years, produced in that empire any change in this respect. The action of the North German confederation, by which the metric system in full became the system of all the Northern States, for domestic as well as for external uses, took place in 1868, as has been already mentioned. In the meantime, other States not connected with the Zollverein, began to fall in with the drift now becoming so general. In 1841 took place the legislation in Switzerland above described, which gave to that confederation a metric system of weights and measures after 1856.

In 1852, Denmark adopted the metric pound of 500 grammes, decimally divided. In 1855, Sweden, without changing the values of her standard units, introduced partially the principle of decimal derivation for the inferior and superior denominations, and this by a later enactment of 1865, she has extended through her whole system. In Spain and her colonies, the metric system was established by law in 1859, the names of the units having been partially transformed to bring them into harmony with the language, the metre being called the metro, the litre the litro, etc. In 1864, the metric system was established in Portugal, and at a period which I cannot exactly state, it was adopted by the Kingdom of Greece. Even Turkey has recently made a beginning toward bringing her system into harmony with that which is now so rapidly becoming the system of all continental Europe, by giving to her unit of length, the archine, the value of 75 centimetres, or three-quarters of a metre. In Great Britain, by an act of Parliament passed in 1864, the metric system is legalized, though it has not been made compulsory. In 1864, another act making the metric the exclusive system for Great Britain, passed its second reading in the House of Commons, having thus reached a stage of legislation where the final passage of a bill is commonly regarded as assured, when it was withdrawn by its originators, as yet premature; but the fact of this remarkable success is a signal evidence of the state of opinion among the enlightened classes of the British people, and a plain premonition of what Great Britain will sooner or later do. In our own

country the use of the metric system in business transactions was legalized by act of Congress of July 26, 1866. The same act provided that postages should be charged in accordance with a scale of metric weights; a letter weighing 15 grammes or less to be chargeable with but one rate of postage. This provision of law, which was practically in favor of the people who use the post-office to a sensible degree, 15 grammes, exceeding the previous local postage weight by nearly 13 grains, or about 1-17th, was, as I am informed, by the effect of a statute passed the following day, quite unintentionally repealed. This second act was designed to regulate postage with foreign countries and it provided that, for postal purposes, ½ oz. avoirdupois should be "deemed and taken to be the equivalent of 15 grammes." The department has applied this provision to the act of the preceding day; so that we have Congress going through with the solemn farce of enacting that the limiting weight of a single letter shall be 15 grammes, but then that these 15 grammes shall be deemed and taken to be only ½ oz.

Undoubtedly the stationery on which these provisions of law were written must be deemed and taken to be a dead loss to the nation. But could anything more forcibly illustrate the liability to error and confusion arising out of diversity of systems of weight and measure, than this example, wherein we see even our highest legislative body when entangled in the maze, incapable of making laws to express its own intentions.

In South America, the metric system has been adopted by Brazil (to take full effect in 1873), in the Argentine Republic, in Uruguay, in Chili and in New Granada. In North America, it is established by law in Mexico. According to the best authorities I have been able to find, the total population of Europe approaches 260,000,000, of whom about 135,000,000 have already accepted the metric system in all its details, or have given to all the standard units of their own systems metric values. Add to these 25,000,000 more in Mexico and South America, and we have a total of 160,000,000 of civilized people in Christian lands who are irrevocably committed to the metric system; while a considerable proportion of the rest have made progress toward this system by adopting metric values in part, like Denmark, and Austria, and Turkey, or by adopting the decimal law of derivation without as yet the metric values, like Sweden; and 70,000,000 more, the people of the British Islands and the United States, have made the use of the denominations of the system lawful in all business transactions within their territory. All this has been accomplished by the pressure of public opinion; it has been distinctively a movement of the people and not of governments; it is a social rather than a political phenomenon. When the metric system was first introduced into France, the pressure came from above, and was resisted by those upon whom it pressed. The people did not understand the system and they did not want it. In the discussions which we hear going on about us concerning it at the present time, the opponents of the system seem constantly to assume that the same plan is to be pursued to-day; and that there exists somewhere an insidious design to force the system upon peoples whether they like it or not. That, I take it, is not the spirit of the modern propaganda. Neither the British people nor the American people are expected to accept this system unless they think it best; but the presumption of some of us is that they will sooner or later think it best.

But why, it may with justice be inquired, are our people so far behind those of the continent of Europe in appreciating the value of the metric system? This is to be accounted for by the same reasons which make them comparatively indifferent to the existence of *any* international system of weights and measures. In a large country like ours, widely separated from the rest of the world, the inconvenience of metrological diversity is immediately and personally felt by the individual citizen only on rare occasions; when, for example, he travels in a foreign country, or when in his own he meets a foreigner raw to our institutions, or when he attempts to obtain some exact information, from the publications of other countries; while the disadvantages to which it daily subjects him operate in a manner so indirect, and are mixed up too with so many other matters, that he fails to connect them with their causes. We can easily understand the state of things which would exist, if we had no public standard of weights and

measures at all; and if every tradesman made his own system and sold his customer, say, so much for so much. This plan is illustrated in Diedrich Knickerbocker's account of the dealings of the early settlers of the Nieuw Nederlandts with the Indians—"every Dutchman's hand weighed a pound, and every Dutchman's foot weighed two pounds." The inconvenience and uncertainty of trade would be only a little less, if, instead of having as many systems as there are tradesmen, we should have as many as there are villages. If, for instance, while a man can get on very comfortably among his immediate neighbors, he finds himself, on driving four or five miles, entirely at sea on the subject of quantities, he will be scarcely able to prosecute any business of magnitude without an amount of trouble and confusion quite intolerable. Enlarge the communities within which common systems prevail, and separate them more widely from those which employ different systems, and the evils which, in the original supposition, embarrassed individuals, now affect the transactions which take place between these communities. Operations are larger, and they are mainly conducted by a particular class; but the misapprehensions, the delays, and the increased expense attendant on these operations are charged, like the customs duties, upon the whole community, without their being clearly conscious of the fact. Our custom houses, and our great importing houses, are compelled, by the diversity of weights, measures and moneys with which they have to deal, to employ an immense staff of computers, whose sole business is to effect transformations of values upon the invoices of the commodities which pass through their hands; and the salaries of all these employés are undoubtedly paid by the consumers of the commodities.

Now, on the continent of Europe, where, in the central part at least, the territories of independent States have heretofore been small, while the population is dense, the evil of a multiplicity of systems of weight and measure, and of custom-house lines occurring every 10, 20, or 30 miles, has been felt as, of course, we can never feel it; and, therefore, there is nothing surprising in the fact, that the people of those States have perceived the need of a common system to be pressing, when we were not thinking of the matter at all. Nor is it any more surprising that, in looking about for a common system, and finding the metric system to be an existing system, and a good system, and, above all, an available system, and the only one apparently available for the purpose, they should have seized upon it and legalized it, and made it permanent, without too anxiously concerning themselves with the questions whether the metre would not have been better if it had been a little longer or a little shorter, or if it had represented something different from what it does represent, or whether, in fact, it does, after all, really represent anything at all.

Considering, therefore, the nature of the causes which have induced 135,000,000 of the people of Europe to adopt the metric system; and considering, furthermore, that in Denmark, Sweden, Austria and Turkey we have 55,000,000 more who have shown by their legislation their appreciation of the merits of this system, or of the principles on which it is founded, it may, I think, be safely said, that the universal extension of this system over the continent of Europe is only a question of time.

Besides the causes which I have mentioned out of which the important changes I have just described have grown, it is to be remembered that there are other influences of a very powerful description actively at work to recommend the metric system to the favorable consideration of the peoples which have not yet received it. The principal of these peoples are the English-speaking nations, and the inhabitants of the Russian Empire. Now for a very long period it has been true that the great body of the scientific men of our own country, of Great Britain and of Russia, have been thoroughly impressed with the value of the metric system; and many of them have been constantly in the habit of using it. That there has been here and there a dissenter may be admitted. Here as elsewhere, *exceptio probat regulam.* But a dissenter who, like Sir John Herschel, holds that the system is good, but that the base ought to have been a ten-millionth part of something else, rather than of a quadrant of the meridian, is not much of a dissenter after all; and one who, like Capt. Piazzi Smyth, bases his metrological theories on religious grounds, and prefers the

pyramid inch as his standard, as a matter of conscience, is not likely to concentrate around him a very powerful party of opposition.

Scientific associations in the countries just named have memorialized their Governments in favor of the metric system. The British Association for the Advancement of Science has done this repeatedly, and the Imperial Academy of Sciences of St. Petersburg has done it likewise. In the year 1866, the National Academy of Sciences of the United States, on the report of a committee with Prof. Henry of the Smithsonian Institute at its head, a committee which had had for two years the subject in its charge, addressed a memorial to the Congress of the United States expressing the sense of the Academy as to the importance of establishing an international system of weights and measures, and recommending the metric system as the best existing.

The scientific journals throughout the world give evidence of the growing practice of scientific investigators of using metric values in their experiments, in their calculations, and in their writings. This began in Germany very early. I find it to be true of Poggendorff's Annalen so long ago as the year 1800. At the present time, it is next to impossible to find any other system of weights and measures but the metric, so much as occasionally named in any of the publications devoted to physics] and chemistry in all Germany. Almost the same thing is true of the scientific periodicals of Russia, of Austria, of Denmark, and of Sweden. I have very recently looked through the principal journals of this class, published in the countries just named, and what I assert of them, I assert from personal knowledge. Men of science have adopted this system, not only because of their approval of its principles, but because it is a labor-saving machine of immense capabilities. If you look into our own scientific journals and those of Great Britain, you will find that what has just been remarked of the journals of the Continent is true to a considerable extent of them also, and to an extent constantly increasing. Our analytic chemists use the metric system altogether; and with our physicists its use is becoming every day more general. With the science of the world on its side, therefore, the metric system has a powerful ally, which, added to the influence of the material interests enlisted in its favor, must make its final triumph inevitable.

It will be understood that the scientific associations, and the scientific men to whom reference is here made, are those who deal with the exact sciences, or employ themselves with material nature. Truth is the object of their search—with the uses of the truth discovered, or its relations to the human race, they do not concern themselves. There is, however, another class of inquirers, one to which I have earlier referred, whose influence on the question before us is destined to be powerfully felt, who have created in these modern times a new science of their own, taking as their subject precisely what the former class omits—the relations of truth to humanity. In the scope of their inquiries, they are most widely comprehensive, embracing equally all truth—the moral and the psychological no less than the physical. They call their science social science ; it might be called the philosophy of philanthropy, for its object is to discover and remove the causes of human wretchedness, whether they be material, political, mental or moral, and to place the human race in circumstances where it may work out for itself a destiny the noblest of which it is by nature capable. It is not through a merely native taste or bias, that these men pursue the science they have created. Their science is to them more than a love : it is a religion. Their impelling principle is deeper than enthusiasm: it is an earnest sense of duty. These men, therefore, belong to that class whose characters command the highest respect, and whose opinions carry the largest weight among their fellow-men. They, too, like others, have availed themselves of the powerful machinery of associated effort. In many enlightened lands, social science associations hold their periodical meetings, and by means of the reports of their discussions, scattered among the people through the public prints, and the wide circulation of their own memoirs and journals. powerfully impress the public mind. Within the past ten or fifteen years, there has sprung up, in addition to the national organizations here referred to, an International Social Science Association also, composed of men of every land, many of them men whose names have a world-wide celebrity. The

last meeting of this influential body was held in 1867; the next is to assemble in England, during the ensuing fall. Among other measures adopted at the meeting preceding the last, was the appointment of a committee to draw up a complete code of international law, to be presented for acceptance to the governments of all nations, and to be binding upon all such as shall assent to its provisions. The code is to comprehend two grand divisions, presenting the rights and duties of nations, first in peace, and secondly in war. The first of these divisions, relating to peace, is now complete, and will be presented to the association at the ensuing meeting. I am authoritatively informed that it embraces provisions making the metric system of weights and measures, the common system for all the nations accepting the code; and there can be no doubt that the association will cordially concur with their committee as to these provisions. The Social Science Associations may therefore be regarded as another powerful influence, silently acting throughout every corner of every civilized land, and throwing its whole strength in favor of the universal adoption of the metric system of weights and measures.

There are other influences co-operating with this, in which the political principle is combined with the social. The importance of endeavoring, in some way or other, to arrive at a common system of moneys, weights and measures, has been felt by governments to be sufficient to justify the calling of international conferences to discuss this very thing. Now, though these conferences have not resulted as yet in bringing actually to pass the object for which they were summoned, still they have furnished an independent and an important vindication of the extent to which public opininion everywhere is turning toward the metric system, as destined inevitably to be at length the system of all mankind. For while the money question has invariably elicited a large variety of opinion, and an agreement of all the delegates upon any one proposition for the unification of the coinage of the world has been found extremely difficult if not impossible to secure, yet as to the question of weights and measures, there has been no difficulty whatever. At the Paris conference of 1867, for example, 22 nations were represented, including the non-metric nations, Russia, Austria, Sweden, Denmark, Great Britain, the United States and Turkey. The committee report in favor of the metric system was an admirable document drawn up by the celebrated De Jacobi, of St. Petersburg, and it received the absolutely unanimous concurrence of all the delegates of all the nations. It is impossible to regard a phenomenon of this kind, without seeing in it both an indication and an influence—an indication showing the march of opinion hitherto, and an influence which cannot fail to be felt in accelerating this march.

But there is still another and more powerful influence, uniting like that last mentioned, the social and political features, which has been gradually taking shape and gathering strength within the past twenty years, which is also destined to act powerfully in favor of the speedy creation of an international system of weights and measures, and which is already committed in advance to the metric system for that purpose. In explanation of this remark I will state that, about twenty years ago, there was assembled at Brussels, on the invitation of the Government of Belgium, a convention which assumed the name of "the First International Statistical Congress." This body consisted of 236 members, who were about equally divided between Belgium and foreign countries, thirty-five being delegates appointed by governments. This first convention, held in 1853, has been followed by six others, of which the second was assembled in Paris, in 1855, the third at Vienna, in 1857, the fourth at London, in 1860, the fifth at Berlin, in 1863, the sixth at Florence, in 1867, and the seventh at the Hague, in 1869. The spirit which these great international assemblages originated is explained in the following brief extract from the report of Mr. S. B. Ruggles, of New York, the delegate from the United States,* to the convention of 1869, at the Hague, recently published by order of the United States Senate. "The distinguished promoters of the first Congress, at Brussels," says Mr. Ruggles, "had seen enough of modern statesmanship to know that the government of nations in their present state of material progress, cannot be wisely conducted

* Mr. Ruggles also ably represented the United States in the fifth Congress at Berlin.

without a thorough knowledge of quantities;" and that the systematic collection and philosophical arrangement of the "quantities" needed for showing the general condition of nations, was an indispensable preliminary to any recommendation by an international Congress of any measures seeking to promote the general welfare." In accordance with this spirit, "the Official Report (or 'compte rendu') of the Congress at Brussels, shows its labors to have been largely devoted to the scientific analysis of quantities, in subjects interesting to all nations, to be used as a basis of a uniform system of inquiries, in actually collecting the necessary facts." And in like manner all the succeeding Congresses have devoted themselves sedulously to the labor of bringing together every description of facts obtainable, in regard to the actual wealth, the productions, natural and artificial, the condition of industry and commerce, the character of the social institutions, and other matters of kindred interest, relating to the various peoples who make up the population of the globe. The results of such inquiries could only be made available for any useful purpose, on the condition that all the "quantities" so ascertained should be reduced to a form in which they could be compared; on the condition, therefore, that they should be expressed in denominations of the same system of weights and measures; and accordingly it has been urgently recommended by all these Congresses, that all statistical statements everywhere should be made in terms of the metric system. The seventh and most recent of these assemblies, moreover, inaugurated a work which, if efficiently prosecuted, will be in honorable harmony with the magnificence of the idea which originated these Congresses of the nations. The nature of this work is thus stated by Mr. Ruggles: "On the last day of the session, Dr. Engel, the distinguished director of the statistical bureau of Prussia, presented to the body, in general assembly, a plan of great comprehensiveness and importance, which had been matured after full discussion in the appropriate section, and conversation with most of the governmental delegates. It provides for a full and systematic exploration of the whole field of international statistical inquiry, which is divided for that purpose under twenty-four different heads, each to be the subject of a separate investigation by the delegates or members from some one of the nations to be selected, and which is to embrace the statistics under that head, of all the nations. The great work, if fully carried out, will furnish, in convenient encyclopedistic form, a systematic series of carefully prepared reports on most of the subjects of highest interest to the statesmen and legislators of the different nations. Editions of at least two thousand copies of each report are to be published in uniform octavo volumes, under regulations presented in the plan, which was unanimously adopted by the Congress, with strong expressions of approbation."

Without the metric system, the vast mass of information thus collected would be unavailable; the encyclopedia would be illegible. This system has, therefore, thus become something more than a mere instrumentality in the service of statistical science, it has become even an integral part of the science itself. Henceforth the two are so irrevocably wedded that they can be separated no more for ever.

The "International Statistical Congress" may now be regarded as an established institution. Its eighth meeting in order of succession will be held some time during the course of the year 1871, and probably in St. Peterburg. Already the influence of its deliberations, of the published results of its labors, and of the spirit of comprehensive statesmanship which it has inculcated and fostered, is beginning to be sensibly felt, and with each successive decade of years it will be felt with a power continually increasing, in educating the minds of the peoples, and in moulding the counsels of governments into harmony with the great principle that nations only then consult their truest interests when they consult the common interests of humanity.

The germ idea of an agency which, with time, has developed itself into a power capable of controlling and destined so largely to control the future of human history, is to be found in the report of Mr. Adams to the House of Representatives of the United States Congress, made in 1821, which has been already cited in this paper. Though this report discouraged the adoption of the metric system by Congress, and though its reasonings had the effect undoubtedly

to impress the popular mind in this country with the conviction that the introduction of the system into these States is hopeless, yet the author himself was as deeply imbued with admiration of this system, considered as a scientific creation, as the warmest of its advocates; and no one felt more profoundly than he how great would be the boon to humanity if one uniform system of weights, measures, and moneys, could be made to prevail everywhere throughout the world. In the view of his large and statesman-like intellect, very many of the embarrassments which attend intercourse between nations, spring from the narrow and selfish legislation which looks only to the immediate interests or convenience of particular communities, and disregards the results to the great family of man. To him all nations and all races are brothers by blood, inheriting the earth as their common patrimony; and though, in the existing state of human society, it is necessary that the artificial lines which divide States from each other should be preserved, it is eminently desirable that for as many purposes as possible, they should be kept out of sight. He, therefore, proposed that the President of the United States should be authorized to invite the governments of the several States having diplomatic relations with that of the Union, to appoint delegates to a Congress of nations, charged with the duty of deliberating upon measures likely to be promotive of the general welfare; but foremost, and especially upon the possibility of establishing a uniform system of weights and measures for all mankind. That this important proposition was productive of no immediate results is attributed by Mr. Ruggles, and with apparent justice, to the political condition of Europe during all the earlier portion of this century, and especially to that compact of political rulers for the suppression of liberal thought, and the stifling of all freedom of political discussion, which the momentous events of recent history have since shattered, known as "the Holy Alliance." Happily, however, at length, to use the vigorous words of Mr. Ruggles, "We find the germ of the general convention, planted by the far-seeing sagacity of Mr. Adams in 1821, though slumbering for a generation beneath the surface, actually fruitifying in 1853, when the first general assemblage of nations by government delegates, and really international in its objects, was convened in Brussels." From this epoch dates a new era in the history of the world's legislation. For the enlarged views of the reciprocal duties, as well as of the true interests of nations in which this great general movement originated, are destined through its instrumentality to impress themselves more and more completely upon human institutions, until statutes shall at length cease to be monuments of ignorance, prejudice, or ignoble jealousies, and the aim of all laws shall be the greatest good of the greatest number. One most important result has already been secured by the action of these Congresses, in that so far as the science of statistics is concerned, so far, we may even say, as the successful conduct of governmental administration is concerned, it has made the metric system of weights and measures a system of universal necessity, and has made a familiar acquaintance with it absolutely indispensable to every statesman, every publicist, every teacher or student of political economy, and every enlightened lawgiver throughout the world.

It thus appears that there are powerful, permanent, and all-pervading influences steadily at work to advance the cause of metrological reform, and that these influences conspire to forward the movement in the direction which it had already spontaneously taken, that is to say toward the ultimate prevalence of the metric system of weights and measures over every other. It further appears that the actual progress which the movement has made since the century began, has by far exceeded anything which could have been reasonably anticipated, and has been sufficient to justify the most sanguine hopes for the future. When we consider, for example, that, at the close of the last century, the simple measure of length called the foot had not less than fifty values still, probably many more, actually in use in different parts of Europe, and that in 1867, at an Exposition in which the measures of all the world were all brought together, there could be found only eight of this discordant class still surviving, argument would seem to be needless in behalf of a cause which is so manifestly making its own way unaided. Whether our own people are to

be participators in this grand movement which has already gone so far, is not with me a question of probabilities, but only a question of time. I expect very little to-day, and not much to-morrow; but beyond to-day and to-morrow there are other days coming, from which I expect everything. I know the strength of early associations and the power of rooted habits; I know how fondly men will hug the evil which is familiar and reject the good that is strange. I know that the Greenlander greatly prefers his icy mountains to the coral strands of India. My inference is, that we must look to a generation which shall not be so mentally one-sided as ours; a generation in whose training the good shall not be placed at so tremendous a disadvantage as it has been in our own; a generation which shall bring to this great metrological question a judgment at once fair, candid, unbiased, and unwarped by the prejudices which mislead and bewilder us, to pronounce the impartial decision for which, it must be sadly admitted, we seem disqualified ourselves. And such a generation, gentlemen, permit me to predict, will yet be born upon the American continent, if it is not born already.

THE MONT CENIS TUNNEL.

(*Continued from page* 341.)

Having in my last letter given a general idea of the disposition of the external works and workshops at Bardonnèche, I need not describe those at Modane, which are in their principal parts similar. There is only one essential difference between the two, arising from the difference in the local conditions: At Bardonnèche the opening of the tunnel is at the same level (or nearly) as the workshops, whereas, at Modane, it is at a considerable height above them. An inclined plane was therefore established at Modane, on which everything was conveyed up to the mouth of the tunnel from the workshops and the working yards down below.

The motive power in working this inclined plane is the weight of a mass of water confined in receivers adapted for the purpose, which travel up and down the incline, and pull up with their weight (properly regulated by the admission of a greater or smaller quantity of water) the cars loaded with the material, tools, and implements, etc., required for the tunnelling.

MECHANICAL APPLIANCES IN THE MOUNT CENIS TUNNEL.

The mechanical appliances employed in the Mount Cenis Tunnel consist of two separate parts:

1. The plant outside the tunnel.
2. The mechanical means employed in the tunnel for the excavation of the rock itself.

The former may be subdivided into—

(*a*) Ventilation.
(*b*) Transmission of motive power.

The latter consists of—

(*a*) The perforation by the machinery invented by M. Sommeiller, of the holes for blasting.
(*b*) Blasting.
(*c*) Clearing away of the excavated rock.

The requirement of special ventilation and of special excavating appliances, as well as the absolute necessity of a particular kind of motive power, is self-evident when the length of the Mount Cenis Tunnel is taken into consideration.

All who ever have carried on mining are aware of the importance and difficulty of ventilation, when the length of the tunnel becomes excessive. It may be interesting to offer a few remarks on this subject, having a special reference to the means employed in the work we are now describing.

The causes of the vitiation of air in tunnels* are the blasting of the mines and consequent explosion of gunpowder, the combustion of tamps, and the respiration of the workmen.

One pound of gunpowder exploding produces

0.49 lb. carbonic acid gas.
0.10 " oxygen.
0.41 " sulphide of potash.

Now, as atmospheric air fit for respiration only can contain about 5 per cent. of

* J. Fottarappa, C. E.

carbonic acid gas, the explosion of 1 lb. of gunpowder is capable of vitiating $\frac{0.49}{0.005}$ lb., that is 100 lbs. of air, or speaking in volume instead of weight, 45 cubic yards of air, 1 cubic yard of air weighing in round numbers 2.18 lbs.

However, the carbonic acid is not the only gas produced calculated to render air unfit for respiration.

The proportion of oxygen in the air is nearly permanent, being 79 per cent., and if this percentage is increased, air becomes unfit for breathing.

Further, sulphide of potash considerably vitiates air, and hence we may safely admit that 1 lb. of burnt gunpowder impregnates 148½ cubic yards of air.

Now practice has shown that in order to render air fit for respiration in a place where there is no current, from 10 to 13 cubic yards of fresh air per hour have to be introduced for very man employed.

Further, to replace the air consumed by the combustion of each miner's lamp, about 9 cubic yards of air are wanted per hour.

Let us now consider the quantity of air which would have to be consumed for 130 cubic yards of excavated material, excavation being carried on with ordinary means. Practice has shown that in order to excavate 130 cubic yards of hard rock, 400 blasts are required, and 176 lbs. of gunpowder are consumed; further to make 400 blasts 214 days' work are required, calculating a day's work as 12 hours; and, again, as in a gallery, masons, carpenters, etc., are wanted, we may add 120 days' work of 12 hours each.

Supposing, then, that 130 cubic yards of rock should be extracted in 24 hours; during this period of time we shall have to introduce:

	cubic yards.
For 107 miners, and 60 other workmen	52,424
About 83 oil lamps	18,238
To replace the air vitiated by the explosion of 176 lbs. of gunpowder	26,160
For every 130 cubic yards of rock extracted	96,822

Cubic yards of fresh air is required.

Now the section of the tunnel of the Alps having 71¾ sq. yards, in order to advance 1 yard in length in the excavation, if ordinary means were used, about 53,400 cube yards of air would be consumed, and as the total length of the tunnel is 13,364 yards, to perforate it entirely, over 710,000,000 cubic yards of air would be consumed.

Further, the temperature of air must be kept within certain limits to maintain the workmen in a proper condition.

We know that approximately for every 98 ft. of depth attained from the surface of the earth, temperature increases 180 deg. The height of the mountain under which the Mount Cenis Tunnel passes being 5,285 ft., the temperature in the tunnel would be 127.40 deg.; to which we should further add the temperature produced by the burning of gunpowder and the combustion of lamps; we may safely assume the temperature to be 140 deg.

These considerations will clearly show the absolute necessity of a very efficient system of ventilation being adopted, without which the execution of the work would have been utterly impossible; further, the ordinary means used by miners for ventilation were not sufficient, nor indeed were they applicable.

These ordinary means consist of fans which are placed at the mouth of the tunnel, which is divided into an upper and lower chamber, in order to allow the vitiated and more heated air to be drawn along the upper part, and to be replaced by pure air along the lower part of the gallery.

But in tunnels of such excessive length, not only hours, but days would be required before pure air would arrive to the headings, even were the causes of the vitiation of air not permanent.

Hence it was necessary to carry along with great velocity, and compassed in a small volume, a sufficient quantity of air precisely to those parts of the tunnel where the works were concentrated, and the permanent causes of the vitiation of the air existed; or, to speak more correctly, it was indispensable to combine the two means of ventilation.

The exhausting machinery at Bardonnèche consists of a tangential turbine, moved by a column of water 65.7 in. in height. The theoretical velocity is 87 revolutions per minute, and about 40 cube yards of air can be extracted with it per second.

At Modane the exhausting machinery consists of an ordinary pump. As regards the machinery with which compressed air was sent along to the heading in the tun-

nel, they were the same as those with which the motive power was produced, and will be described presently; in fact, the introduction of compressed air in the heading was effected by opening cocks along the tubes which carried the motive power. There certainly was a great inconvenience in using compressed air in the ventilation, owing to the consequent loss of useful work. Let us form an idea of this loss by estimating the quantity of work which can be performed by a cubic metre of compressed air.

$\int p\,d\,v$ represents the work which gas produces in expansion. If we suppose that the gas in expanding absorbs so much heat from the surrounding gas, that its temperature becomes equal to that of the latter, the equation of elasticity of the air will be $p\,v = \mathrm{R}\,t = \cos t$, and hence :

$$\int p\,dv = \int \mathrm{R}\,t\,\frac{d\,v}{v} = \mathrm{R}\,t\int\frac{d\,v}{v} =$$

$$\mathrm{R}\,t\log v + \cos t,$$

will express the work done by the gas through expansion.

And as its temperature remains constant, Mariotte's law receives an application ; the compressed air being supposed by us to expand from a pressure of six atmospheres to that of air, its volume from v_1 will pass to v_0, so far that $v_0 = 3v_1$, and hence the work which the air through its expansion is capable of producing, will be given by the expression :

$$\int_{v_1}^{v_0} r\,d\,v = \mathrm{R}\,t\log\frac{v_0}{v_0} = \mathrm{R}\,t\log 6,$$

or passing from the Napierian to decimal logarithms,

$$\mathrm{R}\,t\log 6 \times 2.30\,;$$

the constant for air is $\mathrm{R} = 29,27$.

The temperature, $t = \alpha + t = 273 + t$, which we will suppose 300 deg. centigrade, and completing the calculation we find 15,718 kilogrammetres as the result.

This calculation refers to 1 kilog. of compressed air, and 1 metre cube of air weighing 1.3 kilog., according to Mariotte's law, the cubic metre of compressed air expanding from the pressures of 6 atmospheres down to that of 1 atmosphere, its volume will become 6 metres cube or nearly, and the weight will be 7.80 kilog.; thus 1 metre cube of air compressed to 6 atmospheres, and expanding down to 1 atmosphere, develops useful work equivalent to 15,718 kilogrammetres $\times$ 7.8 = 122,600 kilogrammetres.

This quantity of work lost by the application of 1 metre cube of air compressed to 6 atmospheres for ventilation is certainly enormous. However, the loss had to be submitted to, in order to make respiration and continual work at the heading possible.

WORKING TORPEDOES.*

By PHILIP BRAHAM.

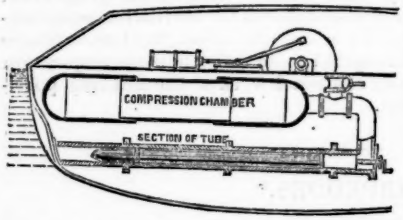
From "Engineering."

The exigencies of modern warfare requiring the greatest amount of damage to be done in the shortest amount of time, and naval warfare being the principal defence of England, the question of using torpedoes has long engaged attention. These destructive implements of war are mere bodies of explosive material, either placed in the way or brought in contact with the ship to be destroyed. The mode commonly adopted is to sink these machines to a slight depth below the water with a fuse at the top, which explodes it when a ship passes over and touches it. Another way is to sink them within view of a camera obscura, and marking the place on the table of that instrument, the wire with which it can be exploded is brought to the observer. A circle is marked on the table, within which the torpedo is effective, and when any aggressive ship comes within that circle, galvanic contact is made with the wire and the explosion is effected ; these modes depend on the ship sailing to its own destruction. There is a proposition that at night a boat's crew might destroy a vessel by one of the party swimming to the ship and attaching a vessel of nitro-glycerine by means of pneumatic pressure, and exploding it by electricity. Another proposal is that two vessels should tow one of these machines

*Description of an apparatus for Working Torpedoes. Paper read before Section G of the British Association.

across the bows of the enemy and then explode it. Another proposition is that the torpedo should be stuck at the end of a bowsprit and run against the enemy.

The method I propose is to propel the torpedo from a ship below its water line by the expansion of compressed air. In the drawing you will perceive the apparatus consists of a chamber into which air can be compressed—a bored cast-iron tube through which the torpedo can be moved—a valve arrangement by which the progressive velocity of the torpedo is obtained, a sluice valve and breech plate, whereby another torpedo can be introduced when the first is expended. The torpedo itself consists of an explosion chamber at the pointed end, with a percussion fuse, a shaft of wood of any convenient length, and a corrugated cap of sufficient weight to make the whole nearly float horizontally. By means of compression pumps driven from the machinery which propels the ship, I propose to compress air into the compression chamber to 500 lbs. to the sq. in. When the apparatus is within striking distance of the object attacked, by turning the lever of a four-



way cock the air will find its way under the piston in the small cylinder, which will rise, and with it draw the brass valve opening a port of the shape shown in black. The first opening of the valve will allow but little air to escape (to overcome the vis inertiæ and friction of the torpedo and the column of water in front of it); then the aperture rapidly increasing in area as the valve pipe rises, a steadily progressive velocity will be imparted to the torpedo of sufficient energy to carry it in a straight line far beyond the ship. By the reaction of the force driving the torpedo forward, the ship will have its speed considerably diminished, if not entirely neutralized. With sunk torpedoes two boats at night with a rope between them could easily fish them up. The diving suggestion would be impracticable in any but still water. The drawing across the bows would depend upon two ships, which are not easy to control in unison. The running end on might involve you in the destruction intended for the enemy, and would bring you unpleasantly near their fire. In my arrangement it must be allowed that the torpedo will be effective at its own length from the bow, and also at double that distance. The reaction from sending this body forward with an elastic pressure, whose average statical force would be not less than 85 tons on the diameter of 1 ft. 9 in. shown, would certainly act like a buffer, and considerably retard the motion of the ship.

A new and very commodious station was opened recently at Pontefract for the convenience of the inhabitants residing at the Tanshelf end of the town, as well as for the accommodation of the vast traffic during the race meetings at that town. The building is composed of pressed red and white bricks, and is set apart as a booking and station-master's office, general and ladies' and gentlemen's waiting rooms. Two very lengthy platforms, 15 ft. in width, have been provided, with 5 gas lights on each side. The contractor for the work is Mr. Gregson, of Wakefield. Five trains arrive and depart from the station daily, which cannot but prove a great convenience to the inhabitants, who, in a short time, will be brought into the immediate locality by the opening out of several new collieries. The station has been built by the Lancashire and Yorkshire Railway Company.

Mr. Charles Dion, of New York, proposes to place an apparatus on board of steamers and other vessels, so arranged as to sound an alarm on approaching the vicinity of an iceberg. The device is arranged on the bottom of the vessel, and is of such a nature that when the keel strikes any very cold strata of water the alarm is sounded. It is well known that icebergs refrigerate the water around them for a considerable distance. Mr. Dion's instrument will exhibit the exact temperature of the water below the vessel at all times.

WHAT IS BEING DONE TO PREVENT STEAM-BOILER EXPLOSIONS?

By ROBERT CREUZBAUR.

After every unusual calamitous boiler explosion, the subject is taken up again and again for discussion ; but, so far, without any results to which we can look for future immunity.

The discussions usually run in two extremes--either laying the cause entirely to weakness in the construction of the boiler ; or, on the other hand, to causes entirely independent of the strain-resisting capacity of the same. These extreme views generally counteract each other, and nothing results. The proposition herein emphatically advocated is this, that however much difference of opinion as to the precise causes of explosions may continue to exist, an overwhelming plurality of sound opinions can agree upon few and simple remedies, capable of counteracting all the causes mooted. These remedies do not necessitate the use of anybody's patent, but are free to all.

With the best efforts to cling to brevity, it is impossible to handle the subject intelligently in a short article. But, as a matter in which every person is directly interested, strictly necessary departure from brevity may be allowed.

Public expectation turned to the Westfield explosion ; and particularly to the report of the able officers of the Government on the subject. From that report it is evident that its framers lay all their trust in the power of resistance of the boiler. And although the injurious effect of unequal expansion is especially referred to, no means are proposed to prevent it. The report says : " . . . the explosion was produced, we think, by a pressure not much in excess of the engineer's statement " (27 lbs.). " We cannot, of course, say that this boiler would not have exploded during the time of one year from the date of the last inspection, had the pressure been confined within the limits prescribed by the inspector's certificate ; but the inference is a legitimate one, that it would not have exploded at the time it did; and it is fair to presume that it might have been used until the end of 12 months without accident." Here, then, is an admission that, had the engineer been ever so careful, the boiler might have exploded within the year, notwithstanding the inspection and the locked safety valve, and the certificate to its power of resistance. Comment on this is unnecessary. The people's dread of boilers is certainly not allayed by this report ; nor are Messrs. Boole and Hill satisfied with the slender security portrayed in it.

The community may, however, feel reassured by the fact that the public officers in charge of the matter are men of too much experience, too great ability, and too sincerely in earnest in their desire to give security to the people in the matter, to allow any conviction of their own as to the cause of boiler explosions to stand in the way of the adoption of remedial measures, which, while fully covering their own view of the causes, would also cover all other views sustained by authorities commanding equal respect. Younger men, with less ability, would be inclined to stand by their own opinions. But older men, of superior acquirements and enlarged experience, generally learn how cautiously conclusions must be arrived at, and are more ready to admit a doubt as to the soundness of preconceived and habitually followed ideas.

Differences of opinion on this subject are not surprising, when it is remembered that, in the words of Prof. Tyndall, " We are more ignorant of these things than we ought to be. Experimental science has brought a series of true causes to light, which may produce these terrible catastrophes, but practical science has not yet determined the extent to which they actually come into operation." The true causes of violent explosions have but recently been urged, and have not as yet generally received that attention which will no doubt be bestowed upon them hereafter. Many of the ablest engineers have found themselves too closely engaged, by the very reason of their superior abilities, to keep step by constant reading with recent experimental science, which proves that causes, formerly discarded by the educated professional engineer, are too well based on fixed laws of nature to be longer ignored.

Before proceeding farther I cannot re-

frain from making allusion to the popular belief as to the relation to each other of science and practice. There is too much inclination to believe the two as antagonistic. The practical community, purely so, is too apt to believe science as unnecessary, and as worthless when seemingly in conflict with their views culled from practice only. This is totally wrong, and is apt to lead to baneful results. What is science? It is the utilizing of knowledge obtained by experience and experiments, so as to apply it to endless other matter with useful results, which, by practice alone, might never be reached. Solitary facts ascertained by practice, are put together to form theories applicable to endless purposes. Facts ascertained by experimental and practical experience, are, figuratively, as the blocks of stone out of which the priceless temple of knowledge is constructed. Without the experimental and practical work the scientific men could never have built that temple for want of material. Hence to reach a maximum of usefulness let them go hand in hand.

Too much stress is generally laid upon personal experience, and is made particularly prominent in this boiler explosion investigation. Men of 30 and 40 years of "practical experience" made assertions totally at variance with that of thousands of others who trained their experience by that of others well proved. Practical men, who do not test their conclusions by the recorded proven experience of so many illustrious men who preceded them, are but too apt to check progress by erroneous statements, not of the facts ascertained, but of the causes they assume to produce such facts. A man, without knowledge of recorded experience, may, for 40 years, handle the starting bar, or build and manage boilers and engines, or superintend the doing of it, and yet know nothing of the nature of steam, of water, of heat, of combustion—in fact, is doing his work at the risk of explosions and other mishaps, by following a groove of habit in which he has learned to travel, and out of which it is extremely difficult to draw him. Let it be remembered that all personal experiences and opinions must be weighed by, and compared with, that of thousands of others, and, by laws of nature, which to deny were as idle as to deny the correctness of the multiplication table.

The proposition herein advanced is this: Perfe t continuous circulation in a boiler, both in the water and steam spaces will prevent all explosions by whatsoever cause, provided it has been proven of due strength by a properly conducted inspection, and is duly supplied with appurtenances.

To prove this, the alleged causes must be, more or less briefly, looked into.

The suggested prominent causes of explosions may be ranged in four classes:

Class A, comprises all that tends to weaken the power of resistance of the boiler.

Classes B, C and D, comprise all causes to which explosions are attributed, without reference to the power of resistance of the boiler.

To class A belong: Imperfect materials. Imperfect mode of putting the parts together. Want of provision for unequal expansion and contraction. Deterioration of materials while in use. As to these, there is very little difference of opinion, hence, no necessity to dwell upon them. It must be remarked, however, that unequal expansion caused by unusual overheating of the metal, it is claimed, is sometimes so excessive as to be the direct as well indirect cause of explosion in the manner named here below.

To Class B belong: Safety valves which refuse to relieve the boiler at the fixed limit of pressure. Inefficient pressure and test gauges. Want of proper connections, and other requirements about all of which there is no dispute.

To Class C belong: Incrustations. Low water. And now come alleged causes ranged in Class D, about which there exist great differences of opinion. Some of these, if not provided against, are considered capable to override all other possible precautions, and to produce the most violent explosions. These are:

1. Highly superheated steam, by its alleged capacity to create a sudden conversion of water into steam.

2. Rapid formation of steam by red-hot plates.

3. Decomposition of steam by red-hot plates, and explosion of the resultant hydrogen gas by commixture with oxygen, etc.

The following three causes may be considered jointly :

4. Repulsion of water by overheated metal, called "the spheroidal state" of water.

5. Narrow water spaces around intensely heated fire spaces,—also resulting in overheated metal and the "spheroidal state of water."

6. The capacity of quiescent water, when deprived of air, to accumulate a large amount of heat over and above that due to its pressure, which flashes into steam.

7. To this may be added electrical and atmospheric influences.

To review these :

1. Is superheated steam capable of producing an explosion? During the investigation referred to, two distinguished engineers, "of many years experience," have answered that question in the affirmative Upon closer investigation they would no doubt express a modified opinion. Let us see : Steam at 25 lbs. pressure has a normal heat of 267 deg. Suppose 700 cubic ft. of such steam be overheated (superheated) to an average of 500 deg., —233 deg. above its normal heat. 700 cubic ft., or 70 lbs., require $70 \times 233 \times 0.85$, or 13.863 units of heat to be thus heated. It takes 926 units to convert 1 lb. of water at 276 deg. into steam ; 13,863 less about 500 units absorbed by the steam at the higher pressure, will produce about $14\frac{1}{2}$ lbs. of steam, which would increase the pressure to about 33 lbs. This is the greatest effect such superheating could produce, and is only possible on the supposition that none of the heat is absorbed by the water not so evaporated, which under this increase of pressure has the capacity to absorb nearly 20 additional units per lb. without forming steam. And it also assumes an extreme in this, that all the steam must become normal in heat, that is, of 286 deg. It must, moreover, be remembered that this increased pressure could only be produced gradually, in fact less rapidly, on account of steam being a bad conductor, than if the steam were formed by heat transmitted through the plates directly to the water. If the steam, by some means, were violently mixed with the water, a sudden formation of steam would even then not take place, because of the capacity of the water to absorb large quantities of heat under increasing pressure. The water, of a bulk eqnal to the steam space, can absorb those 13.863 units of heat without raising its temperature more than about one-third of one deg., if equally transmitted throughout the same,—with an increase of pressure hardly appreciable. This is, however, another extreme assumption, as in a boiler without good circulation, the upper water only would come in contact with the superheated steam. Therefore, the effect of superheated steam in increasing pressure, can be no more rapid than by the application of heat to the water in a normal manner, from the furnace through the metal directly, and thus such steam can be no greater source of explosion than any normal transmission of heat whatever.

The investigations of the Franklin Institute, as stated by its Secretary in a letter of Sept. 4, 1871, which I have the honor herewith to submit, are averse to the proposition that superheated steam can produce explosion.

But whatever the effect of such steam may still be supposed to be by some of its advocates, the prominent remedy which is intended to be urged throughout this paper as universal against explosions from all causes belonging to classes C and D, is perfect and continuous circulation throughout the boiler.

2. Will red-hot plates, suddenly brought in contact with water, form steam of explosive force? That is, does it form steam very suddenly and in a dangerous manner as compared to the normal mode of producing steam. The decomposition of steam is not to be considered under this head, but simply the direct evaporating powers of the hot iron. Let a surface $\frac{1}{4}$ in. thick, 6 ft. wide (the top of 6 flues), 20 ft. long, be supposed to have become heated to 1,200 deg., or about 850 deg. above its usual heat. This is certainly an extreme supposition. The bulk would be $6 \times 20 \times 0.25$, divided by 12, equal to $2\frac{1}{2}$ cubic ft. or 1.215 lbs. The units of heat required to raise this weight of iron through 850 deg. would be $1{,}215 \times 850 \times 0.12$, equal to 123,930 units. The units of heat above 32 deg. contained in the water and steam (700 cubic ft. of each) at 25 lbs. pressure, amount to 10,450,000 units, or about 84 times as much as the surplus contained in the heated iron ; the latter would not be sufficient to heat the whole mass to correspond to a pressure of two additional

lbs. But if, as most likely would be the case, the majority of the heat would produce steam without heating the bulk of the water, the pressure would be very much increased. If no heat were absorbed by the water not evaporated, the greatest assumable result would be an addition of some 134 lbs. of steam to the 70 lbs. already on hand. But this, as in the former case, cannot take place suddenly,—nor as rapidly as the application of the same amount of heat in the usual way, until the iron has become considerably cooled. When so cooled, you have nothing more than unobjectionable highly efficient heating surface, upon which point the instructive letter aforesaid remarks: "The temperature of the maximum evaporation from metallic surfaces increases with the quantity of water brought into contact with them," and is only about 40 deg. lower than that of perfect repulsion. This again points to circulation. The letter farther says· "Explosive steam may be generated by the injection of water upon red hot iron," and that "the committee reproduced the phenomenon of a miniature explosion fron the cause here named;" reference is made to Vol. XVIII., p. 16 "Journal Franklin Institute." This result cannot be ascribed to the evaporative capacity of the hot iron, but is brought about by cause 4, which fully explains it, as shown farther on. The evaporative capacity of red hot iron can therefore, as such, not be productive of explosion, any more so than an equal amount of heat applied in the usual desirable way in the most efficacious manner. The injury would be caused by the great expansion of the parts so heated, and by reduced resistance of the iron itself. And the question is, how much heat has accumulated in the water during the repulsion, ready to flash into steam of explosive force. In the spheroidal state, experiments show the water not to accumulate heat; but the spheroidal and quiescent or deaerated state of water may sometimes occur, in fact are they not likely to occur at the same time? In this case again, perfect circulation in the water and steam is urged as the best remedy known. This does not mean, however, that the proper water level should be neglected. It should on the contrary be made as nearly constant as automatic means can make it.

3. Decomposition of steam by red hot plates, and alleged consequent explosion. That this can take place is as pertinaciously asserted by the purely practical men, as it is denied by the scientific men. The aforesaid letter says: "The reply of the committee as to the truth or falsity of the 'Gas Theory' is decided. They find no reason for supporting it, and their experiments (Vol. XVII., p. 217), as well as the universal sentiment of scientific men, will condemn it as unworthy of being seriously entertained." The same view is held by Faraday as related on p. 8, Jan. 4, 1868, "Scientific American." Nevertheless, a feeling of insecurity in this respect is not surprising, when cases as the following are reflected upon. That hydrogen gas is set free under such circumstances is not denied by either side. The only question is, can sufficient oxygen be mixed with it in a boiler to make it explosive,—and will the red hot iron ignite it in the steam space?

On p. 35 Vol. XIX., July, 1868, "Scientific American," an interesting case is given: "The supply pipe refused to deliver water, and the engineer prudently drew his fire; 24 hours after, the engineer opened the man-hole to see if any damage had been done by overheating. He introduced a lamp, when an explosion occurred sending the engineer through a wooden partition," etc. An explanation of this is given on p. 118, Aug. 19, 1868, "Scientific American," by Doctor Vander Weyde, the correctness of which is not likely to be disputed,—as follows: "Some part of the boiler became hot enough to decompose steam, not into its elements (this is pure speculation, having no fact to support it), but the iron became oxidized by the oxygen of the water, and the hydrogen was set free, which is always the case when steam is in contact with red hot iron. It is, in fact, one of the ways to manufacture hydrogen. The boiler being closed, and the hydrogen not soluble in water, it remained there; when the man-hole was opened, air enough entered to form with the hydrogen an explosive mixture, to which the engineer set fire with his lamp." To this he adds in substance: "Had there been oxygen and hydrogen mechanically mixed, in the proportion as chemically combined in water, something much worse would have happened to the engineer and the boiler also. In this case, it was simply hydrogen and common air,

which may be considered almost harmless when compared with the tremendous power of hydrogen and oxygen."

The legitimate deduction from this is, that a very little oxygen mixed with the hydrogen can cause a little explosion, and more oxygen a greater one, and so on. This is strikingly supported on p. 10, July 3, 1869, "Scientific American," the article relating a misadventure that happened to Prof. Silliman at a lecture, in explaining the properties of hydrogen: "After stating that on a lighted candle being applied to it, it would burn quietly with a bluish flame, he raised by its knob a glass receiver which he supposed was filled with the gas, and applied the candle. There was a violent explosion." He remarked: "This illustrates something that I was going to speak of by and by. A little oxygen was accidentally mixed with the hydrogen, and caused the explosion. We will now try another jar, which I presume we shall find pure."

Who will tell us with what minimum of oxygen the gas will not explode at all, and if ever so weak an explosion, can it be made a harmless phenomenon in a boiler? The steam is often mentioned as preventing the ignition of the hydrogen mixture. Is it not legitimate to admit that the gas, when first produced might be sufficiently separate from the steam for a time, they being also of totally different specific gravity, to ignite by contact with the hot iron? Is all the oxygen absorbed by the iron? Might not a sufficiency remain to cause a very gentle explosion? Does the feed-water carry in a supply sufficient for the purpose? How about iron when hot being permeable to hydrogen gas? If it fails to ignite 99 times, might it not do so the hundredth time?

I do do not say the "Gas Theory" is correct, but these are ideas that might make one set uneasily upon a boiler in which these experiments were going on. Again, perfect circulation in the boiler is the remedy. Before taking leave of local overheating of boilers, the injury done to the structure, independent of any other strain whatsoever, is strikingly illustrated by an incident given on p. 262, "Scientific American," Oct. 13, 1866: "A return flue boiler of 72 in. shell had its plates bulged over the furnace. While workmen were engaged in cutting them out, having chipped an opening of several inches in the forward end, the after end tore apart with a tremendous noise. The rupture took place in one of the transverse seams of the boiler, tearing the solid iron between the rivets about $\frac{1}{8}$ of an in. apart, and 1 ft. in length." This is purely the result of repeated local overheating.

As to the 4th, 5th, and 6th causes, embracing the repulsion of water by overheated metal, narrow water spaces around intensely heated fire spaces, and the capacity of quiescent deaerated water to accumulate a large amount of heat over and above that due to its pressure; about these the evidences to establish their reality are too strong to be thoughtlessly set aside. As they are more or less identical or related to each other, and result fatally in a similar manner, they are considered jointly. Before me is a pamphlet headed, "Is the Donny Theory, or 'Superheated,' or Deaerated Water a Fallacy?" by Geo. B. Brayton, Boston, who offers a reward of $1,000 for proof that water can be superheated as mentioned in the 6th clause. Mr. Brayton calls the theory "absurd," and Mr. A. Guthrie, late Supervising Inspector, who is quoted in the pamphlet, speaks of it thus: "That this theory has been copied into many works on chemistry and science, and assented to by learned men during 100 years, excites my wonder; but that it has not found its refutation in its own absurdity seems to me still more singular." Query: Did Mr. Guthrie think the matter absurd while he was making his experiments? If so, he could hardly be considered qualified for such delicate tests, which require a mind free of preconceived ideas as to the result, and one that can admit success in the experiment as possible; or does he call it absurd because he did not succeed in the experiments? Many more might make the attempt and not succeed; but that would not disprove that the experiment has been successfully made. And lucky that it is exceedingly difficult to fulfil all the conditions required to place water in that state, else there would be a great many explosions. Mr. Guthrie says: "I concede that Prof. Tyndall has in a measure given credit to this theory, but the moment after, and before concluding, he disclaims his belief in it so plainly that he need not be misunderstood." I have be-

fore me the 2d edition of Tyndall's Lectures on "Heat considered as a Mode of Motion," 1865. He explains this property of water on pages 113, 114, 115, and 116. He shows by actual experiment that water deprived of air in a glass tube has a different sound "like that of solid against solid," "that it refuses to behave like a liquid body," "it declines to obey the law of gravity." He says: "Water thus freed of air can be raised to a temperature 100 deg. F., and more, above its ordinary boiling point, without ebullition. But mark what takes place when the liquid does boil; it has an enormous excess of heat stored up; the locked atoms finally part company, but they do so with the violence of a spring which suddenly breaks under strong tension, and ebullition is converted into explosion." "That it does so has been proved by Mr. Faraday. He melted pure ice under spirit of turpentine, and found that the liquid thus formed could be heated far beyond its boiling point, and that the rupture of the liquid, by heating, took place with almost explosive violence." He states: "The number of explosions which have occurred just as the engineer turned on the steam is quite surprising." And after explaining the manner in which the cohesion of the water would bring about such explosions, he closes with, "I do not say this is the case, but who can say it is not the case? We have been dealing throughout with a real agency, which is certainly competent, if its power be invoked to produce the effects which have been ascribed to it." Where does Mr. Guthrie find any sentence indicating that he "disclaims his belief in it?" Is it the cautious exclamation, "I do not say this is the case?" This is an expression of caution natural to men on the pinnacle of science. They feel somewhat as the great philosopher of ancient times, who exclaimed on his death-bed, "I have learned enough to know that I know nothing!" Yes, the more these giants in knowledge learn, the humbler they are in their pretensions, and the more cautious in their assertions.

It is generally conceded that the French officials are capable and reliable. M. A. Ortolon, then Chief Engineer of the Imperial Marine, promulgated a paper upon premonitory indications of explosions. He does not pretend to explain the causes, but merely states the facts to him known to exist, and the remedies: "A fulminant explosion is rarely preceded by any characteristic signs; nevertheless the following phenomena are sometimes the precursors of the catastrophe. Steam alone appears in the gauge glass; although the fires may be strong the pressure falls on the pressure gauge; the boiler tubes and fire-box plates bend, assuming a lighter color; the safety valve rises suddenly, emitting a violent jet of water; the level of the water in the gauge glass remains completely immovable, whilst the pressure falls sensibly without apparent cause." These phenomena are in accordance with the spheroidal and cohesive state of the water. When the plates become too hot to remain in contact with the water, the formation of steam becomes very slow, hence the "falling of the pressure." The overheating of the plates increases as the formation of steam decreases. The water in resisting cohesion is finally violently thrown up, and thus escapes by the safety valve. He farther states: "Renew the water in part at each new lighting of the fire, if it has previously been heated and not completely cooled; this is in order not to leave for the production of steam a liquid from which the air has been completely expelled." Again, "When the engine has been stopped, do not allow the water and steam to remain a long time in the boiler in complete repose." Mr. Ortolon's experience and knowledge unquestionably point to causes 4, 5, and 6, and his remedies coincide with that herein urged.

The "Spheroidal State" theory Prof. Tyndall explained and proved by experiments, as related in the said work on pages 163 to 171 inclusive. He says: "Boiler explosions have also been ascribed to the water in the boiler assuming the spheroidal state, the sudden development of steam, by subsequent contact with the heated metal" (and by release of the heat stored in the water, if deaërated) "causing the explosion. We are more ignorant of these things than we ought to be. Experimental science has brought a series of true causes to light, which may produce these terrible catastrophes; but practical science has not yet determined the extent to which they actually come into operation." "Here is a copper vessel, with a neck stopped with a cork, through which

half an inch of fine glass tubing passes. I heat the copper vessel, and pour into it a little water. The liquid is now in the spheroidal state. I cork the vessel, and the small quantity of steam developed, while the water remains spheroidal, escapes through the glass tube. I now remove the vessel from the lamp, and wait for a minute or two: the water will soon come in contact with the copper; it now does so, and the cork is driven, as if by the explosion of gunpowder, to a considerable height into the air."

In a paper read by E. B. Marten before the Institution of Engineers of Scotland, May 31, 1870, is stated: "It has long been the object of engineers to obtain accurate records of every case of boiler explosion, and I have done my utmost to assist in that object, and have obtained notice of more than 1,500 explosions, causing the death of over 5,000 persons, and the injury of some 4,000 others." "The records are discouraging in many respects, as they contain the names of some of the best and most careful engineering firms as owners of exploded boilers, and also give instances of explosion of nearly every form of boiler which has been in use for any length of time." This would surely not be the case if the power of resistance of the boiler alone could be made to prevent explosions.

On p. 359 "Scientific American," Dec. 3, 1870, mention is made of the pamphlet of J. E. Robinson, steam engineer, Boston, which ought to be in the hands of every boiler manager. It embraces the following particularly notable points: "While it is true that the condition of many boilers now in use is such, that it is a matter of surprise that so few boiler explosions occur, having their origin in excessive pressure, overheating of the surfaces above the water, in defects of materials of construction, and in the presence of scale and sediment, it is also true that there have been so many explosions not attributable to either of these causes, as to point unmistakably to the existence and operation of a power not indicated by the pressure gauge." After giving accounts of a large number of such explosions, Mr. Robinson proceeds to account for such explosions by referring them to "overheating near the bottom of the boiler (by the spheroidal state of the boiler), causing the water to be thrown with such force as to break the top." He supports this by opinions of Boutigny, Bourne, and Colburn, and quotes the experiments made by a committee of the Franklin Institute, showing that the temperature for perfect repulsion for a clean steam boiler is 385 deg., and for one "highly oxidated, but clean," 433 deg. "The temperature of maximum vaporization is some 40 deg. lower." "At the temperature of perfect repulsion the water does not wet the metal." By elaborate experiments he ascertained that "The effect of pressure, accompanied by rapid circulation, so far overcomes the repulsion that, practically, the point of perfect repulsion may be said to be raised by the pressure within the boiler; but this only holds true so *long as there is perfect circulation* of the water, so as to bring it into forcible contact with such surface." "His experiments show, that whenever any part of the surface of a steam boiler much below the surface of the water is raised much above the temperature of maximum vaporization, the reduction of its temperature will be attended with such rapidity of vaporization as to endanger the boiler" (the danger is from other causes); and that, while in cases of perfect repulsion there will always be recognizable signs of trouble within the boiler, indicated by the steam and water gauges, in cases where the repulsion is not perfect, the danger may be incurred without any visible sign of its existence being manifested." This agrees with Ortolon's experience, above quoted.

A very simple experiment, within the reach of all, will sufficiently prove this spheroidal state. I made it with a cast-iron disk with turned-up edges, about 7 in. in diameter, and of $\frac{3}{8}$ in. average thickness. Being made red hot, and withdrawn from the fire, I poured from a teaspoon to a gill of water into it, during several experiments, with the result as above stated. The vapor produced during the repulsion is invisible, therefore supposed to be dry steam. A proof that forcible contact does overcome the repulsion, is obtained by dropping the water from a height of a few inches upon the hot iron, with the result of rapidly extracting the heat at the spot thus impinged upon, as shown by its immediate change of color to a dark red and gray. With the larger quantity of water in the vessel, as soon as the repulsion was overcome by the cooling of the iron, the rapid forma-

tion of cloudy steam in the central part of the disk ruptured it—the hotter outside rim not allowing the central part to contract. M. Boutigny and others maintain (and it is easily tested), that when the repulsion "has once taken place, the plate, being left dry, *may go on accumulating heat and rising in temperature for an indefinite time*, until some agitation, or the introduction of cold water, shall produce contact between the water and the plate, and bring about an explosion."

Mr. Joseph A. Miller, of New York, made some experiments to prove the importance of a *free circulation of water*. They are given and illustrated on p. 180 Vol. VI. (April 1, 1868), of the "American Artisan." Mr. Miller believes that no boiler with a proper safety valve can explode in which there is a perfect circulation, and in which the steam is made to leave the water as fast as generated; or, to use his own language, "no boiler can explode which contains only dry steam and solid water, if a proper safety-valve is used." Mr. Miller wishes it to be understood that by explosion he means, not a simple rupture of the weakest part, letting out sufficient steam to reduce the pressure, but a violent action by which the steam, and generally all the water, are forced out. He took a flask "strong enough to stand a pressure of 50 lbs. to the square inch, on which I placed a safety-valve so arranged that it would lift suddenly at 30 lbs. pressure." "After the flask had been 15 minutes on the fire, the safety-valve opened entirely, a powerful jet of steam was forced out of the opening, and, instantly after, the flask burst with a loud report, shattered every pane of glass in the windows, and destroyed the plastering of the ceiling. The time between the two explosions was infinitely short, and seemed to me just sufficient to force the water against the upper part of the flask, when the whole was shattered into fragments." There was no special provision for circulation in this flask. The same experiment was repeated with a flask provided with a shield to cause circulation, which prevented all explosive action.

Upon the investigation of the Westfield explosion, the idea was advanced that no increased pressure is ever noticed upon starting the engine after the water in the boiler has been allowed to remain quiescent for a considerable time; the deduction being that no sudden development of steam takes place from heat accumulated in the water. To show this to be an error, I quote from "Engineering": "In many cases there is a sudden increase of pressure in steam boilers immediately after starting the engine." Even if such sudden increase of pressure were not observed, it is more than probable that the masses set in motion by explosive development of steam would destroy the boiler before an opportunity is had to examine the gauge; or before a sensible impression upon the latter is made through the reprehensible, crooked, and diminutive pipes leading to the same.

The two following explosions took place in this city, with identical new boilers, in an identical manner, and are worthy special notice. The Dinsmore upright boiler, illustrated in the "Scientific American," p. 357, Vol. XVI., June 8, 1867, has a peculiar construction which seems to obstruct circulation in the parts most exposed to intense heat. One of these boilers exploded "with terrible violence" on board the lighter Enterprise, on January 22d, 1867, just as the tug was entering her dock. The boiler was not quite one year old, and made of No. 2 iron, said to be of the first quality. The boat at the time was ramming her way through heavy ice. The boiler (some 12,000 lbs.) rose bodily from the boat, and fell in the rear of a wall, 40 ft. high, and at least 600 ft. distant, and could not have attained a height of less than 500 or 600 ft. "The tube cylinder (which is about 3 ft. below the common water level) seems to have given way first). See p. 168, Vol. XVI., "Scientific American."

Is it likely that, while ramming ice, the water would not be looked to?

On the 9th of September, same year, another Dinsmore boiler, weighing 5 tons, exploded about 4 P. M., at 258 W. 28th st., ascending into the air nearly vertically, appearing the size of a nail-keg, and falling into the rear part of No. 308 W. 28th st., a distance horizontally of about 450 ft. This boiler was new, having been in use less than two months and a half. The iron was pronounced of good quality by all practical iron men. On the afternoon of the explosion it was not doing more than about half its ordinary

work. The engine was running, and had not been stopped.

The lower tube head blew out, taking most of the tubes with it, which pulled out of the upper head, the latter being about 3 ft. below the usual water level, and 20 in. below the crown sheet. The same engineer and fireman (both killed) had been employed there, as such, about four years. See p. 250, Vol. XVII., "Scientific American."

Now, let us see if the plea of low water, a cause always plausible to its advocates, can be advanced in this case. The boiler contained about 1,300 gals., or 10,875 lbs. of water, and about the same quantity, 174 cubic ft., of steam. The pressure intended to operate the safety valve was 60 lbs. per in. Supposing the pressure to have been up to this maximum, the stored available power for destruction, allowing no stored up heat in the water above that due to its pressure, would be about 56,500,000 ft. lbs.*

This force, after the boiler once gave way, was exerted and spent in every direction, and included the part expended in tearing the boiler. Therefore, scarcely 25 per cent. of it, or about 14 millions ft. lbs. could have been active in propelling the boiler into the air. The height to which it arose is indicated by its "nearly vertical" ascension, together with the base of the parabola forming its path—450 ft., and by its appearance in the air, "about the size of a nail-keg,—(its size 14 ft. high, 7 ft. average diameter). Assuming the altitude at four times the base of the parabola, the former would be about $\frac{1}{3}$ of a mile. This would indicate an initial velocity of the boiler of 336 ft. To allow for atmospheric resistance, 350 ft. is assumed. The boiler weighed 11,000 lbs., and would require $\frac{11000 \times 350^2}{64.32}$—or 21,000,000 ft. lbs., to give it that velocity. The boiler gave way at the upper head of the tube cylinder, where, owing to the construction of the boiler, steam would accumulate, and prevent contact of the water with the metal. This part was some 20 in. below the crown sheet, and about 3 ft. below the usual water level. Had the water been below that tube sheet, the boiler would have contained only about half the usual amount of water, and the total force developed would have been only about 28,000,000 ft. lbs., or only about 7,000,000 to propel the boiler, while a force of over 21,000,000 ft. lbs., seem to have been expended on the latter. The deficiency is still more striking, when the above remark is applied. "It was not doing more than about half its ordinary work," implying a low pressure.

These data are not very satisfactory, it is true. But there are points about these cases unmistakably indicating something more sudden than the normal formation of steam, however rapid, which can never result in a blow, that being the distinctive feature of an explosion as compared to a rupture. If it was a gradual overpressure that hurled these boilers into the air, why did they give way endways on both ends of the tube cylinder; why not sideways in the line of least resistance? The boiler of the Starbuck, with some 56 lbs. pressure, and plates in places not over $\frac{1}{64}$ of an in. thick, was only rent, the opening scarcely admitting a knife blade. Why did it not explode? What causes the appearance in parts of some exploded boilers as if a cannon ball had passed through?

The proposition that electricity and other atmospheric influences may have something to do with explosions, cannot contemptuously be cast aside. Faraday's and Armstrong's experiments show that electric sparks, from 1 to 2 ft. long (if I remember correctly), may be obtained from a small boiler while the steam is in motion. There is the significant fact, that with a trace of salt in the water, no such sparks can be obtained! Has this

* This quantity is only about ¼ of that arrived at by Nystrom's formula, which I do not consider correct in practice. The following calculation, given in accordance with the logic upon which the operation is based, will explain. The heat above 32 deg. F., in 10,875 lbs. of water at 60 lbs. pressure above the atmosphere is 3,025,600 units. At atmospheric pressure this water retains 1,968,400 units; and the balance of 1,157,200 units supply the latent heat to evaporate about 1,175 lbs. of that water. The first lb. evaporated will have a pressure of nearly 60+15 lbs., and the last lb. will be a little over atmospheric pressure. But the mean pressure is much below the average of the two, because the water, in losing a high pressure, does not surrender as much heat per pound as at lower pressures. The calculation is complex, although very interesting to those fond of this mental exercise. To make sure of arriving at an approximately correct average, I divided the range between 60+15 lbs. and atmospheric pressure into 12 parts, and calculated each part separately, to wit: The amount of heat surrendered by the water; the amount of water evaporated by it; the pressure and amount of steam thus obtained, and the work stored in it in expanding to atmospheric pressure. By this mode, the reasons for every step taken remain clear, and are easily followed to the end. From the result obtained, the actual work corresponding to one unit of heat, must be deducted for every 772 ft. lbs. of work obtained, because that much heat disappears, or rather is converted into work, and is, therefore, not available to continue expansion. The expansion of the 174 cubic ft. of steam gives out about 1,500,000 ft. lbs., less the deduction just named.

anything to do with the coincidence that the explosion of a boiler at sea (using salt water more or less) is something very rare, almost unheard of? John Wise says, as stated on p. 189, "Scientific American," March 19, 1870: "When I drop water on a hot plate, below a red heat, it rolls about without making noise or steam. When the spheroid is rolled over the edge of the hot plate on to one of lower temperature, it explodes. If, however, it be struck with a hammer while rolling about on the hot plate, *it goes off like a fulminate*, resembling the crepitating noise of thunder, as heard by an observer immediately above the cloud in which it occurs." Mr. Wise thinks the phenomenon electrical, and as such, he thinks, violent explosions in connection with it are readily explained. Electrical phenomena are not all understood. Tyndall's remark, that he had not even a theory about magnetism is a very striking one, and applicable to other matter. I am in possession now of electrical phenomena, proved to be a reality, which no one has as yet been able to force even into a plausible theory.

In the face of all this, would it be wise to insist that nothing of the kind alleged in class D can occur, and that a strong boiler, with plenty of water and a good safety valve, is all sufficient? Sooner or later the Government may create a bureau of experiments which could remove doubt on these subjects, and save millions in property and thousands of lives, now destroyed by casualties caused by misapplying and ignoring the forces of nature. Such a bureau could disseminate, in a concise pamphlet form, the most necessary directions in the management of boilers, as prescribed instructions, to which might be added properly prepared blanks, upon which every engineer thus instructed, and interested in the matter, could (and most of them would) record any remarkable phenomena. These records, collected periodically, and the data thus obtained properly tabulated, would serve to improve steam engineering in general, and would lead to the discovery of phenomena having a disturbing influence upon boilers.

In the meantime, what shall be done? To admit that explosions are caused by other agencies than gradual over-pressure, does not in the least detract from the vigilance required to preserve the direct capacity of resistance of a boiler. But on the other hand, to ignore these other causes, let them be doubted ever so much, would seem as logical as to treat a purported keg of sand, as to which some doubt exists, whether it may not be a keg of powder, with as little protection against ignition, as a keg of sand would require.

Does circulation in the least degree decrease the power of resistance of a boiler?

Is not circulation the best agent for rapid formation of steam, and best possible protection against overheating of metal from any cause, in fact the pre-eminent requirement in a good boiler, without regard to explosion? It may be applied in a variety of ways. By mechanical means through power; by automatic means. By the constant pumping in of some air with feed water or separately. And especially by constant feeding, or at least constant when the engine is not in operation. The circulation caused by the feed water, however, is not sufficient under all circumstances.

It has been seriously proposed to discard the hydrostatic test. The question arises, why discard it? and what is to be substituted in its place? The proposition is here made, that such a test properly made, is perfectly reliable. All authors on the limit of elasticity of iron, or, in other words, the limit to which it may be strained without injuring its power of resistance, place that limit above two-fifths of the breaking resistance. If, therefore, a boiler is tested to one-third of its ultimate strength, no injury can be done. The working pressure should be half that. The special purpose of the test is to ascertain whether the assumed or calculated power of resistance really exists. For example, judging by the construction, materials, etc., a boiler is assumed to be able to stand with perfect safety, say a working pressure of 25 lbs. It is tested at 50 lbs. Merely to get up that pressure for a minute or so, would prove nothing; it might, in fact, injure the boiler so as to burst with a lower pressure. But if the 50 lbs. can be kept up with a slight and *steady* feeding by the pump (to make up for slight weeping of the boiler)—say for an hour, without any sudden giving way or sinking of the pressure, and without requiring irregularities in the feeding up—the boiler has not been injured by the test, and is safe at half that as a working pressure. This course should be pursued

whether the boiler be new or old. It is difficult to conceive on what ground an old boiler should be tested on less than double the working pressure, if that is made the rule for a new one.

Let an inspector receive an ample salary, and forfeit a heavy amount, retained from his salary, for every explosion of a boiler by him certified to as in order. The majority, it is hoped, will do their full duty without any extra incentive. They will nevertheless not object to the higher salary, with the risk (if any), as giving a greater feeling of security to the people. There is another class, however, whom nature has not constituted cautious, and with whom recklessness, even when their own lives are concerned, cannot be shaken off. These are not fit for inspectors under any circumstances.

STRAINS IN TRUSSES.—No. IV.

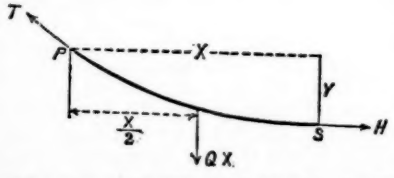
THEORY OF PARABOLIC GIRDERS.

It has already been shown that the strains in a parabolic girder may be found by the method of static moments, without knowledge of the usual theory applicable to such a girder.

Two peculiarities were discovered by this method: that under full load the strains in horizontal members are at the maximum and are equal; and that under full load, the strains in diagonals are zero. The second principle is a corollary of the first, for if $X = X_1$ (horizontal strains), then any diagonal strain Y must be zero.

It will be useful to determine upon what conditions these properties depend. A knowledge of them is necessary, not only to find the strains in a given girder, but also to determine the form adapted to given strains.

Suppose a chain fixed at two points A and B, hanging in equilibrium, and with its weight uniformly distributed along its horizontal span, the unit weight being q. Suppose the chain to be cut at the lowest point S, where the strain is horizontal, and that the chain is kept in the same position by a force H. This must be horizontal in direction, otherwise it would pull the ends out of their position. Suppose the chain cut at another point P, and that equilibrium is maintained by a force T.



The piece S P (Fig 1.) is kept in equilibrium by 3 forces, H, T, and the resultant of the weights distributed along S P. This last force is $q\,x$; x being horizontal distance between S and P. It acts at the distance $\frac{x}{2}$ from either end, the load being uniformly distributed.

The equation of moments, P being the centre of moments, is

$$(1) \qquad H\,y = q\,x\,\frac{x}{2}$$

As the point P is arbitrary, this equations holds for all points, *e. g.*, for A, where $x = l$ and $y = f$; l being the half-span, and f the depth at centre.

$$(2) \qquad H\,f = q\,l\,\frac{l}{2}$$

Dividing (1) by (2) we have

$$(3) \qquad \frac{y}{f} = \frac{x^2}{l^2}$$

The same conditions hold for the section S B. By means of equation (3) the position of various points may be found by substituting for x given values and solving the equation for y. These points lie in a parabola, the form of which depends upon the magnitudes of f and l.

The following principles are deduced from the above investigation:

First.—The horizontal strain produced by T is equal to H at all points, and is therefore equal at A and B.

Second.—The vertical component of T is $q\,x$; and at the points of suspension is $q\,l$.

Third.—The tension T is equal to

$$\sqrt{H^2 + V^2}.$$

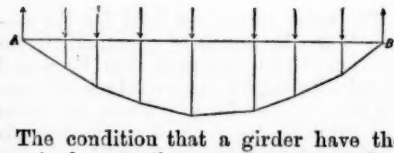
It follows that any particular points of the chain will remain in the parabola, if they receive loads which will satisfy equa-

tions (1) and (2). This happens when the loads are concentrated at points on both sides of S, so that each point bears the ½ of each adjacent section. For the whole load on the section S P is still $q\,x$, and its lever arm $\frac{x}{2}$, as the centre of gravity, remains at the middle. Such a condition may be caused by verticals which transfer the strains of the load to the supporting chain. As the unloaded portion of a stretched chain is rectilinear, the whole length takes the form of a polygon inscribed in a parabola. This is the case even if the vertex S is not loaded. For suppose any piece to be cut out and that equilibrium is maintained by the forces T, T_1; then, that there may be no turning about P, we must have

$$T_1\, t = q\, x \frac{x}{2},$$

t being the lever arm of T_1; and it is easily shown that the same form of equation would hold for any other section supposed cut out.

If the two points A and B receive vertical resistances only, both the horizontal forces H must be represented by the reactions of a horizontal piece fixed between the abutments, which may be regarded as composed of several pieces. This gives a parabolic girder of the form represented in Fig. 2, which is capable of supporting a uniformly distributed load without diagonals.



The condition that a girder have the required properties may be expressed as follows:

The points of support of vertical members must lie in a parabola whose axis coincides with the central vertical line of the construction.

The above results are applicable in the case when the forces act in opposite directions; the convexity of the parabola being taken upwards.

The Camden and Amboy Railroad has not yet passed under the control of its lessees, the Pennsylvania Railroad Company.

From the "Manufacturer and Builder," we learn that the ingenuity of the American mechanic has found an eccentric interpreter in W. I. Trafton, of Manchester, N. H., who is making the smallest possible specimen of an engine. Every part of it is constructed out of a silver half-dollar. The boiler is to hold about 8 drops of water, but with 4 drops the engine can be worked several minutes. When finished, it is to be placed under a glass case ¾ in. in diameter, and 1½ in. in height. Some of the parts will be so fine and delicate that they cannot be made without the use of a magnifying glass.

According to the "Food Journal," New York is beginning to feel the influence of the completion of the Pacific Railway. Formerly teas were imported *via* the Isthmus of Panama, but now this route is superseded by the shipments forwarded from San Francisco by the new overland line. If the railway freight is not too heavy, New York can thus be more cheaply supplied than by sea, while the qualities will be fresher and altogether superior. The ultimate effect will be that New York will not only be converted from an import to an export trading station, but that all the teas, silks, and other Asiatic products will be forwarded through it for the supply of Europe.

Mr. Proctor is engaged in the construction of an isographic chart of the northern heavens, in which are to be included all the stars (324,000 in number) of Argelander's noble series of charts. Mr. Proctor's object in charting these stars on a single sheet is to endeavor to ascertain what laws of distribution exist among the stars of the first 9 or 10 orders of magnitude. Struve has already examined a portion of the same list of stars with a somewhat similar object; but as he dealt only with numerical relations, and these relating only to averages, it seems not unlikely that the presentation of all the 324,000 stars in a single view, all the details of their arrangement being preserved, may lead to results of extreme interest.

STRENGTH OF IRON TUBES.

From "The Engineer."

So long as any structure of either an engineering or architectural character retains its form under the ordinary conditions of the load it is intended to carry, or undergoes only such an alteration in its normal shape as is consistent with its design, so long may it be regarded as secure, and equal to the duty imposed upon it. But directly the relative position of its several parts becomes changed so as to exceed this limit, then there is danger of its downfall taking place. Hence it is not sufficient in designing an iron bridge or roof, that the respective members of it should be adequately proportioned to resist the strains to which they will be subjected, as it is essential that provision should be made that they should always be in a position to perform that duty. The difficulty of insuring this constant feature in structures increases in a very high ratio with the dimensions and complexity of the design. The tendency to deformation—by which term is understood any alteration from the normal shape—augments considerably with the number of individual parts and the separate connections that are present. Hence, to guard against deformation has always been one of the principal difficulties which engineers have had to contend with, especially since the employment of iron on a large scale for works of construction. If a solid beam deflect beyond a certain limit, or if a wall bulge outwards or inwards too much, the eye, aided by a little common sense, will perceive the danger; but in structures of a more complicated description the evil is not detected in so simple a manner. A, comparatively speaking, very slight deformation in a compound trussed girder, for example, will suffice to disarrange the accurate adjustment of the strains, and by bringing members of the truss into compression which would otherwise be in extension, and *vice versa*, seriously jeopardize the stability of the structure. So long as the dimensions of bridges and roofs remained small, there existed but little risk, as the quantity of material superfluously introduced was more than sufficient to leave a margin of safety which under no possible circumstance could be exceeded. But this method of getting on the safe side of danger was no longer admissible when the structures assumed what were once considered gigantic proportions; and more scientific and precise means had to be adopted to meet the requirements of cases that presented themselves.

It is, no doubt, within the memory of our readers that the two great dangers the promoters of the Britannia Bridge over the Menai Straits had to dread, were the imagined force of the wind against the sides of the tubes, and the alleged probable deformation of the top and bottom, more particularly the former of these two. To say that fears on these grounds were altogether groundless would be as false to assert as that the dangers possessed the magnitude imagined. One result of them was that experiments were instituted with the view of investigating the comparative value of different sections of tubular girders, or, more strictly speaking, of tubes proper. These are deserving of much attention, inasmuch as it is very doubtful whether the rectangular form is theoretically or practically the best to adopt in cases similar to that of the Britannia Bridge. This question is of more significance at the present time, because we are in possession of additional information respecting the other forms of tubes which was not at our command then. But, omitting all consideration of this, there were sufficient data at hand at the time of the carrying on of the experiments relative to the Menai Bridge, to warrant a more extended investigation into the merits of the cylindrical and elliptical sections. Although the idea of employing cast iron as the material for a bridge across the Straits was speedily abandoned by Stephenson, in consequence of the opposition displayed by the Admiralty and other parties interested in the navigation, yet the question of the relative strength of cast-iron tubes of different sections was submitted to actual experiment. A certain number of square, round, oval, and rectangular tubes were subjected to a direct breaking weight, and the separate results carefully compared. In experiments of this character,

in which the object aimed at is the determination of the best form of section in which to utilize a material, it is essential, in order to avoid complicated calculations, that the quantity of material should be the same in all the sections experimented upon. Thus, in the instance alluded to, the tubes were all of the same thickness, although the depth and width necessarily varied. There was very little difference between the strength of the square, round, and rectangular tubes, but the increase of depth in the oval example at once gave it a great advantage over the other forms. With the same amount of material, and consequently with the same weight, the oval tube showed an increase of strength amounting to nearly 50 per cent. above the other sections. But this result must not be regarded as proof that the elliptically shaped section is absolutely the best form to resist a transverse strain under all conditions of proportion and distribution of material. If the element of depth be eliminated from the calculation, or what amounts to the same, if the depth and sectional area be common to all, then the square tube will afford the greatest resistance. The square is therefore, *per se*, the strongest form, since, the depth being the same, it derives no special advantage from that important dimension over and above that enjoyed by the other forms. Consequently the superior result is due solely to its particular shape, but there are practical reasons for giving the preference to the round tube in all ordinary applications of the material in a hollow form.

It is admitted now that the experiments carried on at the time of the building of the Britannia Bridge, with respect to the strength of wrought-iron tubes of different shaped sections, were very incomplete, and also that the conclusions arrived at regarding the powers of resistance of the circular and elliptical forms were premature. The fact is, that the fear of deformation led to a too hasty abandonment of these two forms. Under the strains to which they were subjected the circular and elliptical forms soon became distorted; but had care been taken to prevent deformation taking place, there is no doubt the results would have been highly satisfactory. The effect of placing a load upon a circular or oval shaped tube would obviously be to convert the one into an ellipse, and make the other still more elliptical. It is easy to perceive the evil of this. In their normal condition under a load one portion is strained compressively and the other tensilely, but directly deformation occurs this equable distribution of strain no longer prevails. Parts that were in compression became strained in tension, and instead of the top and bottom flanges maintaining their respective distances unaltered from the neutral axis, their relative position was changed, and they performed, more or less, according to the amount of elongation produced, the functions of the web of a girder. Bear in mind the extreme thinness of the tubes, and the absence of all diaphragms, it is obvious that no other result could have been expected. The only precaution taken to prevent deformation was the introduction of wooden blocks in the interior of the tubes over the bearings where the shearing strain reaches a maximum. This precaution is still used in the designing of large girders of either the plate or lattice type, in which the web is invariably strengthened at these points by additional bars and stiffening pieces. In order to effect the same purpose, and increase the rigidity of the structure, it is not an uncommon practice of the French engineers to construct the ends of lattice and open web girders of solid plates. But the best guarantee against the alteration of form in flanges of girders lies in using thick plates, which is the true remedy for buckling. Had thick plates been employed in these experimental tubes, together with a suitable number of diaphragms, the preference might not, perhaps, have been given so unreservedly to the rectangular form of section. The results cannot be considered as a fair criterion of the strength of circular and elliptical tubes, more especially when it is borne in mind that the riveting was of a most inferior description. It is not necessary to investigate the reasons, which were chiefly of a practical nature, that finally led to the adoption of the rectangular section, but it cannot be overlooked that the experiments which were conducted with relation to tubes of that form were as complete and extended as it was possible to make them. Had the same course been adopt-

ed with respect to those of the circular and elliptical form, the fear of deformation would have been soon shown to be groundless, and the superiority of the latter section, in the matter of riveting, which would have been about ¼ of that required in the rectangular tube, would have become very apparent.

The experiments to which reference has been made, relate wholly to the transverse strength of tubes of cast and wrought iron, and have no bearing upon their resistance to longitudinal strains of tension and compression. In other words, a distinction must be made between a tube acting as a beam or girder in itself or in the position of one of the members of a girder. In the latter capacity both cast and wrought iron tubes of very considerable dimensions have been used. While in this position they are not subjected to any transverse strain, but merely resist the horizontal components of the shearing strains arising from the load. But whether they act in one or other of these situations, it is equally imperative to prevent alteration of form by the use of diaphragms. From the fact that cast iron must, for practical reasons, have a much greater thickness, when in the form of a tube, than wrought iron, it is evidently better adapted for the top flange of a large girder than the other material. In the former case the material itself, by virtue of its own thickness, presents a great resistance to any tendency to deformation. In the latter, the whole resistance must be provided for by the employment of additional and extraneous metal. Owing to the numerous accidents which have befallen compound structures in which cast and wrought iron have been employed in combination, there is a strong prejudice against this method of construction. On several occasions we have touched upon this subject, and observed that the greatest care and skill are requisite to insure that a design of this character shall be of a reliable and durable nature. It is not so much want of strength in cast iron as a material for construction, that limits its application in engineering works, as that it is difficult to obtain it in the best form of proper dimensions for works of magnitude.

LOCOMOTIVE ECONOMY.

From "Engineering."

It is not very many years since locomotive engines had to be reckoned amongst the most economical power producers in use. The high-pressure steam with which they have long been worked, their high piston speeds, and the generally good proportions of their boilers and valve gear, gave them, at the time to which we refer, great advantages over most of their competitors, and the consequence was, that, as we have said, the locomotive held in those days a high position amongst engines generally. At the present time, however, matters are greatly changed; high steam pressures and high piston speeds are no longer almost peculiar to locomotive practice, while the development of surface condensation and the compound system have combined to assist in the production of engines capable of developing a horse-power with a consumption of fuel amounting to less than ⅔, probably, of that required in the best locomotive ever built. Even portable engines—long regarded with something not very different from contempt by railway engineers—have, under the fostering care of the Royal Agricultural Society, improved of late years to an extent which renders them, in a large number of instances, more than a match for the locomotive as far as economy of fuel is concerned; and only a few months ago we took occasion to point out that, in some respects, locomotive engineers might now advantageously adopt, with certain modifications, the practice of portable engine builders. Under these circumstances, it appears to us worth while to consider the causes which have contributed to this result, and to explain briefly some points connected with locomotive economy, which we have reason to believe are not so generally understood as they deserve to be.

We have, on former occasions, when writing on steam engine economy, always been careful to point out that the real value of any improvement applied to a

steam engine is dependent in a most important degree upon the nature of the work which that particular engine has to perform. We have shown that the greater the number of hours per annum that an engine is in steam, the greater is the expenditure which it is justifiable to incur to obtain a given percentage of reduction in the consumption of fuel, and *vice versâ*; and we have explained how an improvement which, in one instance, might be adopted with considerable profit, would, if resorted to in another instance, actually cause a monetary loss. Now there is no class of engine to which these arguments apply with greater force than to a locomotive. The average number of hours per annum during which a locomotive is actually running is small, the average power developed when running is considerably below the maximum power which the engine is capable of developing, and hence, the total number of foot-pounds of work developed per annum and the total cost of fuel per annum are both very small in proportion to the cost of the machine. How small this annual cost of fuel per locomotive really is, is probably known to but few beyond those specially concerned in railway management, and we therefore subjoin a table containing some data on this point, which we believe will be interesting. The figures given in this table, we may remark, have been calculated from the returns of ten of our principal railway companies for the last six months of the past year, the "average cost of fuel per engine per half year" being obtained simply by dividing, in each case, the total cost of coke and coal for the half year by the number of engines possessed by the Company.

NAME OF RAILWAY.	Average number of miles run per engine during half year.	Average cost of fuel per engine per half year.
London and North-Western	8,140	£48 19 4
Great Western	8,833	52 17 5
North-Eastern	9,141	83 11 8
Midland	10,740	79 0 0
Great Northern	9,795	67 12 9
Great Eastern	9,797	73 2 3
South-Eastern	8,334	108 0 0
London, Brighton and South Coast	9,961	138 4 11
London and South-Western	12,093	111 19 3
London, Chatham and Dover	10,221	131 0 11
Means of above for half year	9,705½	£89 8 10
Means per engine per annum	19,411	£178 17 8

In round numbers we may call the average cost of fuel per engine per annum £180, and if we take the mean gross cost of an engine as £2,400, we see that the cost of fuel really amounts to an annual charge of but 7½ per cent. on the cost of the machine. In other words, if it were possible, by doubling the cost of construction, to render a locomotive capable of doing its work without any fuel whatever, the saving would, on the average, only pay interest at the rate of 7½ per cent. on the extra outlay, even if we suppose that this outlay involved no increase in the allowance to be made for depreciation. In the case of the London and North-Western Railway, moreover, the interest on the additional outlay, under the circumstances above supposed, would amount to but 4 per cent., a very unremunerative result. In the above instances we have supposed, as we have said, that an extra outlay on the engine involved no extra charges for depreciation; but in reality this, of course, would not be the case. There are, probably, extremely few improvements which are capable of being applied to a locomotive for the purpose of obtaining greater economy of fuel, which will not render necessary an additional allowance for depreciation fully proportional to the increase they cause in the cost of the engine, and if we take this charge for depreciation as 10 per cent., and the interest on extra capital invested as 5 per cent., we shall have a total annual charge of 15 per cent. on the cost of any such improvement as we have sup-

posed, which must be cleared off before the use of the improvement results in a profit. Let us, for instance, suppose a locomotive to be fitted with some fuel-saving arrangements involving an additional cost of £200; then these arrangements would have to save per annum a sufficient amount of fuel to pay an annual charge of £30 (£20 for depreciation and £10 for interest) before the use of these additional appliances was attended with any profit to the railway company to which the locomotive belonged. But £30 is about $\frac{1}{8}$ of the average total annual expenditure for fuel, and therefore, fuel-saving arrangements, such as we have just supposed to be applied, would have to effect a reduction in the consumption of fuel of at least 16$\frac{1}{2}$ per cent. in order to avoid their use being attended with an absolute loss. In the case of the London and North-Western Railway, where the average cost of fuel per engine per annum is less than £100, the £30 above mentioned would represent the cost of rather more than 30 per cent. of the annual consumption of fuel, and the fuel-saving appliances costing £200 would, therefore, have to reduce the consumption more than 30 per cent. before they became profitable.

Assuming that the above-mentioned allowance for depreciation is fairly correct, and making a slight additional allowance for incidental expenses mostly attendant upon the employment of additional parts on an engine, we may consider broadly that any fuel-saving appliances added to a locomotive must, to avoid their use being attended with loss, effect on the average a reduction of fuel amounting to 1 per cent. for each £10 of their original cost. Now, with this fact before us, it is easy to understand why simplicity has always been regarded as a cardinal virtue in a locomotive, and why so few "refinements" have ever been found profitable when applied to it. Notwithstanding this, however, there are a few fuel-saving appliances which, although involving some additional cost, might certainly be very generally employed with advantage. The most important of these are steam jackets for the cylinders, and a simple arrangement of feed-water heater. With the increased pressures of steam now in use, steam jackets are more than ever a necessity for economical expansive working, and we have on a former occasion pointed out how they may be very readily applied to locomotives. Feed-water heaters are, we are glad to say, coming into use on several lines, and we hope to see their employment extended.

So far, in speaking of locomotive economy, we have considered an engine merely as a power-producing machine; but in reality a locomotive is far more than this. Besides being a steam engine proper, it is a carriage on which the engine and the stores of fuel and water for working that engine can be transported from place to place, and this carriage portion of the machine exercises a most important influence upon the question of maintenance. Speaking in general terms, the average total expenditure per locomotive per annum on our main lines of railway may be taken as about £660, this sum being divided out about as follows:

Fuel	28 per cent.
Wages and other running expenses	32 "
Repairs and renewals	35 "
General charges	5 "
	100

Now if we still assume the average value of a locomotive to be £2,400, we shall see that the mere annual charge for interest on this sum taken at 5 per cent. will amount to $\frac{1}{4}$ of the whole annual expense of working and maintenance, or, in other words, that it will be nearly equal to the whole cost of repairs and renewals. If now, by any modification or improvement in construction, we suppose it possible, without increasing the cost, to make one engine do the work which it at present requires two to perform, there would at once be effected a saving, due merely to the reduction of interest charge, equal to that which would be obtained by reducing the consumption of fuel to $\frac{3}{4}$ of its present amount, while there would be the further advantage that the saving resulting from any given improvement in the economical production and use of the steam would be proportionately increased. It is here that we have the key to the true method of securing locomotive economy, and an explanation of the fact that the most successful locomotive superintendents have been those who have paid the greatest attention to the production of a thoroughly durable engine at a moderate cost. It is thus that locomotive engineers have of late years thrown themselves open to the charge of paying more attention to what

may be termed locomotive manufacture, than to the development of the engine as an economical steam user; but a careful consideration of the facts of the case shows that in doing this they have been consulting the best interests of those for whom they act. The greatest aids to locomotive economy are, in fact, such improvements in construction as enable the engines to be worked for long periods without entering the shops for repairs, and such arrangements as enable the engines to run a large annual mileage, without, however, interfering with the proper intervals for cleaning and general overhauling. In fact, so long as the latter points are attended to, the harder locomotives are worked the better will be the economical results. It is impossible, within the scope of the present notice, to do more than direct attention to the general principles we have endeavored to explain, but we intend in future articles to speak of some of the leading points of detail upon which locomotive economy in a great measure depends.

THE CATHEDRAL OF COLOGNE.

From "The Building News."

The double work of restoring and completing this splendid structure goes on, we regret to learn, but slowly. From recent numbers of the "Domblatt," or "Cathedral Leaf," a journal expressly devoted to this one subject, and which empties all its profits into the subscription box, we learn that scarcely any stone was put in, scarcely any money collected, scarcely any work done last year. That, however, need not be a subject of surprise. War and preparations for war do not belong to the harvest times of art in any country; and the mighty shrine of Cologne naturally stood neglected while diplomacy first, and battles afterwards, absorbed the anxieties of Europe. But it is nothing less than marvellous that the Germans—a people of so much national pride—should exhibit apathy, and even parsimony, in respect of their magnificient temple—the crown of all Gothic in continental Europe. Yet so it is. A destiny would almost appear to hang about the building, as though it would never be finished, and as though while the new sprung up the old were foredoomed to decay. We have to remember, in fact, that this is the process actually going on. Month by month, as the central tower of iron rose from its 4 sustaining pillars, deep-rooted in the earth, through the roof and up, in perfect grace and lightness, to a stately and airy height, the grand portico was literally mouldering, and dropping in minute fragments to the ground. The fault lay with the original constructors, who quarried for their stone in the soft and porous cliffs of the Seven Mountains, and, more particularly, among the friable strata of the Drachenfels. Materials of that kind were not calculated to endure for ages, as is testified to by the incessant patchings which the robber knights and feudal princes of the Rhine had to bestow upon their castles, and the rapid crumbling of these edifices after being once abandoned by those who had an interest in preserving them. In fact, were it not for the tourists, who supply an incentive to the conservators guarding the picturesqueness of the Fatherland river, the ruins themselves would speedily be ruined, and sink down in shapeless masses on the rocks. This cause partly accounts for the dilapidation of the incomparable Cathedral which adorns, even in its incompleteness, the most important city of Rhenish Prussia—a province overwhelming with wealth, though begrudging the cost of terminating that task which artists and monarchs gloried to contemplate 6 centuries ago. It is disheartening even for the stranger, who cannot be supposed to share the German pride in this sumptuous trophy of time, to revisit the City of the Three Kings; to revisit, autumn after autumn, and perceive the same melancholy signs of indifference and lassitude—the paltry heaps of unhewn stone, from Andernach and Treves, on the terrace; the sawing and sculpturing yard, unworthy of a third-rate Thames-side contractor; the meagre scaffolding; the few stragglers on the roof; and, above all, the inferior, rough, spiritless, characterless work employed. Within there is an appearance, but only an

appearance, of greater activity. That is to say, the perspective is ruined, as it has been for years past, by forests and frames of timber ; and the wondrous beauty of the choir is threatened with the heavy touch of 19th-century restoration, when it needs no touch whatever, except for the replacing of certain fallen fragments. But a fragment takes a long time to replace in the Cathedral of Cologne. On October 17th, 1434, one of the pinnacles of the gallery running round the vault above the Chapel of the Magi fell down. On October 17th, 1834, 400 years later exactly, it was restored. That is about the rate at which things do move in the capital of the Eleven Thousand Virgins. Passing through the portal, the sculptured beauties of which are rapidly exfoliating themselves out of form, we glance up, as far as may be, through the twilight interiors of the towers, which are to be 500 ft. high, and have not risen a foot for centuries past. They are choked with scaffolding, and not the sound of a hammer, or a chisel, or a trowel, or a man's voice, is heard. You inquire of the sacristan, "When are the workmen here?" "They will be here when there is money to pay them." You may easily believe it. The "Cathedral Gazette" announces the week's subscription, to the fund for carrying on this universal German labor of love—they amount, perhaps to 10s. 6d.! and this is no exaggeration. It is clear that the heart of Germany is not in the giant Dom of Cologne. A quarter of a century has elapsed since a prodigious noise was made, calling upon the entire Fatherland to rescue its proudest monument from the wasting influences which were reducing it to the skeleton of its former self. It had gone on growing through generations. The plans of its unknown architect were taken up—a bit added here and a bit there—and laid aside again. In one reign a few statues were installed in their niches; in another a painted window threw its gilded and jewelled light upon the fractured floor, making it all one treasure ; in a third a patch was put on the roof, or a figure graven for a tomb, to catch the same ruddy and amber rays athwart some saintly face. But at length, 50 years ago, the Germans began to profess themselves ashamed of the sight that was to be seen in the opulent city of Cologne. *Reich wie ein Köllner*—rich as a Cologner—had long been a popular saying. The spectacle was, indeed, to be lamented. Much of the interior was only sheltered by a wooden roof ; the side aisles were not vaulted in ; the two great gables of the north and south front were fragments, though fragments of superb designs, surmounting every other stone structure in the city ; a part even of the exterior wall was wanting ; only a few of the buttresses stood firm ; the nave had to be reroofed and vaulted ; the cross gallery, with its pinnacles and gablets all lovingly indicated in the plans of the unknown architect, had never been erected ; of the parts that had been finished the finer traceries and mouldings were disappearing in decay ; the exterior sculpture exhibited signs of honeycomb ; total destruction, indeed, seemed to impend over the finest structure in Germany, even before it stood as a completed edifice at all. When the architects were called in they reported a degree of unsoundness, ricketiness, and dilapidation by thieves, who had stolen the leaden roofs, besides robbing the altars, that an immediate expenditure of £30,000 was necessary to prop the tottering parts. But the unknown architect was a Titan in his ideas, and what he built of the towers—unsunk and unshaken now—were really intended to bear, and can bear still, the weight of an additional 300 ft., ponderous and massive, which he contemplated rearing upon the 200 ft. already erect, huge, upright, unshaken by time and tempest, solid as rocks—the protectors of that glorious portal beneath whose arch many a noble church might stand, with plenty of place above the spire.

The German Governments, or rather those of Prussia, Wurtemberg, and Bavaria, at last felt compelled, for the honor of a nation which is nothing if not boastful, and has many reasons for boasting, to meditate upon a systematic plan for saving the Cathedral. Little importance can be attached to their resolves, however, until the year 1842 was reached. Then was constructed the machinery which, feebly and spasmodically, is still at work. King Frederick William IV. became a patron, and laid a new foundation-stone, as though the labors of 400 years were beginning over again ; and the Dombauverein, or Cathedral Union, with 1,000

affiliated smaller unions ramifying through the land, was established. It was agreed, in a moment of unmeasured enthusiasm, that Cologne Cathedral should be regarded as a symbol of German unity. By the introduction of this political idea the progress of the task was retarded. Only Munich and Wuttemberg, where German unity is yet scarcely recognized, contributed generous subsidies. But the eagerness of the people was kept up at white heat for a time. The King put himself down for an annual subscription of £1,500 ; the societies collected funds ; lectures, sermons, festivals, were drawn upon as so many sources of help ; strangers were pitilessly sentinelled until they dropped money into the boxes padlocked on every door ; and, when nearly 20 years had elapsed, results were visible. Among others, 1,000,000 of thalers, or 1,000,000 of coins worth 3s. apiece, had been spent. The choir was finished, and its harmony slightly marred. The columns of the nave had been carried up to their destined height, with a less flagrant departure than might have been expected from the original design. The vaulting of the roof was in a fair way towards completion. The 200 ft. of tower had been surveyed, and pronounced not less solidly set in the earth than Ehrenbreitstein itself, and the "Domblatt" had commenced its appeals to the entire Catholic world to aid in the holy triumph at Cologne. But one singular influence was hostile to the Cathedal Union and the Cathedral "Leaf." It is a proverb throughout Rhenish Prussia, and far beyond it, that Cologne Cathedral will never be completed, though, in order to the fulfilment of this prediction it was not necessary to leave it as Napoleon's General found it when he, without the least irony, complimented the inhabitants of the city upon their "magnificent Gothic ruins." Still the laborers were not altogether idle. They declared, 8 years ago, that the interior only wanted a finishing touch. It wants a good many, at any rate, now. It is true that the barbarous partition separating the choir from the nave has at length been removed, so as to afford the hope of an unbroken perspective before long ; and even that every now and then, as if by magic, all the inside scaffolding disappears, when grand ceremonies have to be performed ; but a pilgrimage through the splendid spaces, and still more splendid recesses, of this surpassing edifice, proves that no part of it can yet be called perfect, unless it be the genius that lives in the whole. Nor need we wonder. With all the hubbub, the celebrations, the songs, the appeals, the local organizations, the patronage of princes, the mendicant missions abroad, the countenance of the Pontiff, the pride professed by Germany, and the periodical exaltations of the "Domblatt," we doubt whether any sum approaching to £750,000 sterling English has been expended upon the work from first to last, notwithstanding that the structure was to be adopted as a symbol of German greatness and unity. One thing, however, the restoring architects did accomplish 3 years ago, and every German, whether or not he had or had not subscribed to the Cathedral Restoration and Completion Fund, anticipated that, forthwith, the towers would rise to their predetermined loftiness of 500 ft. above the mound in the Marz Plaz, whereon, tradition records, Agrippina's Roman veterans encamped. They hauled down, in 1868, the ancient and remarkable crane on the south tower, which, for centuries, had been a landmark of the crescent-shaped city, especially from the river. They might have left it until there was masonry to put in its place. Many a tourist, wearying his eye for the Cathedral, first caught sight of the old, well-known, black crane, with its grotesque framework and its beam slanting upwards like a bowsprit. It has disappeared, and, let us hope, is in some museum, for it was probably the only genuine specimen extant of the cranes employed by the builders of the middle ages. That its power was immense is demonstrated by the masses of stone which it must have lifted ; but, among all the florid histories of the Cathedral with which German hand-book literature abounds, we have met with no description of its mechanical principles. As for Schlegel. he, of course, regarded it as no part of his subject, and so soared from the crane into the entities. After their war, however, and the accomplishment of their unity, of which, despite prophecy, the Cologne Dom was not to be a symbol, we may hope for more rapid advances. For the sake of the choir and the majestic south portal alone, if not for the sublime

design of the towers and the luxury of art-thoughts which must have been amassed in the mind of the architect when he traced those aspiring pillars, those wondrous flying buttresses, those giant piers, that dream of purpled pinnacles, and those casket-like chapels which are jewels holding gems. But, it must be repeated, while the new is created the old is perishing, and the old means that which was truest to the typical hope of the founder. For, anxious and conscientious as the first generation of toilers may be, they devote themselves to their Cathedral in an inevitably modern spirit. It is not to them a passion which they yearn to perpetuate by a monument; they labor upon lifeless stone, that refuses to become animate beneath their hands. It is not the pious Parnassus of their ambition ; it is little sacred, little loved, little revered ; it is the world-renowned Cathedral of Cologne, which really must be finished, or it will grow into a scandal. These considerations, forcing themselves upon us, do not justify very exalted hopes. It may even be imagined that the Dom, the ancient of ages, would have been more beautiful and more hallowed as a ruin than it will be when the thrifty German people have counted out thalers sufficient for its completion. Nevertheless, Germany is doing right in attempting, with, however, half a heart, to prevent any such catastrophe ; for though it might not impair the splendor of the shrine in the eyes of those for whom every Basilica upon earth is a shrine, the disgrace to the nation must have been indelible. What inspirations of different times, what labor of numberless hands, what emulations of artists, what struggles against the effects of decay and ravage, do these ascending piles, raised upon such deep foundations, as though the architect had dreamed of immortality for them also, represent. They may be somewhat vulgarized by 19th-century contracts and repairs ; yet, taken for all in all, it is better that a people pretending to greatness should be careful of its sacred monuments, however tardily or slowly, especially when they assume such forms of religious grandeur as Cologne Cathedral, than that they should only admire them as they crumble, and dedicate their purses to the extinction of the arts—a project which is among the latest ebullitions of the Teutonic philosophy. So far for the story of a German architectural "restoration," not yet half on its way to be finished.

RAILWAYS IN CEYLON.

From "The Engineer."

In every instance in which the conveyance of goods alone is the object in view, and time not a question of primary importance, it will be admitted that carriage by water surpasses in cheapness all other known means of transport. To some extent, therefore, it becomes in colonies and undeveloped countries in which facilities for water communication exist, a matter for serious consideration whether those facilities should be improved and extended or practically nullified by the introduction of steam locomotion. It may perhaps be considered that we are going too far in tacitly assuming that the existence of the one description of transport must necessarily involve the extinction of the other. In England and in many other countries the railways and the canals can be seen running almost in parallel contiguity, and there is, if not abundance of work for both, at any rate sufficient to keep them both alive. But there is a vast difference between these instances and that of a young colony or semi-civilized nation, whose wealth consists in land alone, which, until cultivated superficially or explored subterraneously, is worth absolutely nothing. A new country cannot afford two different systems of communication ; it has only traffic for one, and, judging from the results at our command, the preference appears to be given to railways. This is the case even under circumstances in which we might expect the reverse, that is, in districts which are in possession of extensive water communication, which is as much needed for the conveyance of traffic as for the more important purposes of irrigation. It is evident that the same canal cannot well answer for both of these ob-

jects. In the event of a severe drought, in which the supply might be only adequate for one of the purposes, which is to give way, the irrigation or the traffic, and where is compensation to come from for the sufferer? The real reason for the construction of railways in preference to canals is to be found in the character of the districts through which they pass. The mineral wealth of a country rarely lies in the plains; it must be sought for in the mountains, in the regions of gorges and ravines, and in almost inaccessible localities where it is difficult to make a pathway, to say nothing of a railway. Some examples of lines constructed under these difficulties on a comparatively small scale can be witnessed at home, but they sink into insignificance before similar examples in America, the Brazils, India, Ceylon, the Mauritius, and other countries, where the physical obstacles to the construction of railways may be truly termed gigantic.

It is now nearly 4 years since the line was opened from Colombo to Kandy in Ceylon, an island which, by reason of its rugged contours, presents formidable impediments to the advent of the great pioneer of civilization. Although there is abundance of water power available in the island, yet, for the reason already mentioned the utilization of it as a means of transport was never entertained. Mountain torrents, until they are miles and miles distant from their source, cannot be converted into canals. Rather more than 20 years ago a company was formed for the construction of the line from Colombo to Kandy. A concession was sought from Government on the same principle which regulates the granting of similar powers in India, and after a delay of only 10 years it was obtained. As is usual on such occasions, previous to the ratification of the treaty an engineer was deputed on the part of the Government to make a reconnaissance of the country, and report whether in his opinion the line could be made for the sum guaranteed. The Secretary of State appointed the late Captain Moorsoom to undertake the task, who, with the aid of his assistants, examined 6 different routes, ultimately selecting one 80 miles in length, which he reported could be completed for the sum of £857,000, using round numbers. This sum included land, stations, works, permanent way, rolling stock, and all expenses and contingencies incidental to the putting into thorough working order a single line of road It is difficult to understand how any Government could imagine that the total expenses of a line and all its appurtenances, constructed in such a district, could be brought within the moderate sum of £11,000 per mile; but we have the authority of Mr. Molesworth that such was the case, that the concession was granted, and a staff of engineers sent out to survey and lay out the railway, with a view to its immediate progress. No sooner was the intended route definitely settled upon and subjected to a survey in detail than the fallacy of the statement respecting the cost became at once apparent. There are very few preliminary estimates that will stand the test of being worked out in actual practice, but the discrepancy will seldom or ever reach the amount of 100 per cent., as occurred in the case before us. After a full investigation of all the unavoidable difficulties in the shape of gradients, curves, and heavy works which beset the proposed route, the revised estimate attained the figure of £2,214,000. Notwithstanding this increased expenditure the line was of a very unfavorable character. Gradients of 1 in 16 were introduced, together with a stationary engine incline, 3 miles in length, and a couple of reversing stations. It would be scarcely possible to imagine a railway encumbered with features more objectionable. The accident that happened some time ago at the reversing station on a Ghaut in India is sufficient to demonstrate the great danger incurred in their adoption, and an incline worked by a stationary engine is a "trouble for ever."

So great a discrepancy as that which existed between the former and the latter estimates was sufficient to raise grave doubts in the minds of the authorities respecting the actual expenditure that would be required to make the line, and, losing confidence in their own advisers, they referred the whole matter to Mr. Robert Stephenson. The death of this gentleman prevented him carrying out the wishes of the Government, who then placed all the necessary data in the hands of Mr. Hawkshaw, and requested him to report upon the subject. After abolishing the stationary engine incline,

and introducing various modifications in the proposed route, Mr. Hawkshaw came to the conclusion that the total cost would, in all probability, not exceed £1,872,000. In the meantime, while these investigations and calculations were being carried on in England, Mr. Molesworth, who was the chief resident engineer in Ceylon, determined to ascertain whether a better route could not be obtained than that already proposed. As there was still a considerable staff of assistants in the island he employed them, with the concurrence of the Government, in making fresh surveys. The result justified his anticipations, and his exertions were rewarded with the success they deserved. The new line diminished the original distance by 5 miles, and reduced the gradients to so great an extent as to be equivalent to a pecuniary saving of £300,000. In spite of this satisfactory result, and the large expenditure incurred, the contract between the Company and the colony was dissolved by mutual consent, and in 1863 a contract was entered into by the Government with Mr. Faviell for the construction of the line in 4 years. The works would have, no doubt, been completed within the stipulated time but for the severe sickness that occurred in the unhealthy districts. An additional 8 months was accorded to the contractor, and a sum of £58,000 over and above the contract price, making the total cost of way and works to amount to £1,436,000, or a little over £19,000 per mile. The whole of the line has been constructed in a very efficient and durable manner, and the traffic returns which have been published in Mr. Molesworth's report are of the most encouraging character. There is one feature in connection with the estimates for railways in distant countries which deserves notice. It relates especially to the rolling stock, nearly all of which is of home manufacture, and shows that a margin should be always left for contingencies under this head. For some years the cost of work in England requiring skilled labor has been steadily on the increase. It is of little moment now to inquire into the cause, although one need not go far to find it. The lapse of nearly a couple of years was sufficient to produce a considerable rise in the price of the rolling stock exported to Ceylon. Locomotives sent out in 1867 cost £300 more than their predecessors, which were consigned to the Company 2 years previously. Carriages "rose" from £30 to £40 each, and there was a proportionate increase in the price of the inferior description of rolling stock, such as goods wagons, trucks, and other vehicles. When once a line has been regularly opened for traffic, the chief point is to keep the working expenses as low as possible, consistent with efficiency, during the first year or two, and in fact until the whole affair is brought into thorough good working trim the expenses afford no fair criterion of what they ought to be. Thus we find that for the first two years the line from Colombo to Kandy was worked at a loss. In the succeeding year the expenses averaged nearly 59 per cent. of the receipts, and subsequently were gradually reduced to 45, 40, and 36.

According to Pliny, there was no sun-dial in Rome until 11 years before the war with Pyrrhus, about 460 A. U. C., or nearly 300 years before Christ. They were known, however, to the Greeks 2 centuries earlier. The first seem to have been brought from Sicily to Rome, and Pliny complains that they did not suit the latitude, and gave the hours falsely. This evil was "diligently rectified" by a Roman mechanic; and the dial, in various forms, remained the only measure of time for a century and more. About 160 years before Christ, the *clepsydra*, or water clock, was introduced. This was similar in principle to our sand-glass. The water in a vessel was allowed gradually to escape. The first *clepsydræ* were not transparent, and probably they could only, like our hour-glass, mark a single division of time by the escape of all their contents. Subsequently, they were made of glass, and probably provided with graduated scales on which the lapse of the several hours could be perceived.

Many small basins of coal exist in the midst of the Rocky Mountains, not directly connected with the great coal-field along its eastern base, and it is considered likely that some of these basins contain anthracite coal.

THE DURATION OF THE ENGLISH COAL FIELDS.

From "The London Mining Journal."

The Report of the Commissioners appointed to inquire into the several matters relative to coal in the United Kingdom has just been issued. It contains a vast amount of information of the utmost possible utility and interest, and as the Commissioners decided at their first meeting to appoint committees to investigate separate subjects, they have been enabled to perform their duties very completely. The subjects intrusted to the five committees were, the possible depth in working, waste in combustion, waste in working, the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata, and mineral statistics respectively. The Commissioners have had the advantage of paid assistance, and every facility seems to have been offered to them for collecting materials for their report, in the preparation of which the exertions of Mr. J. F. Campbell, the secretary, appear to have been most valuable.

The investigation to determine the maximum depth to which it would be possible to work coal has not been conclusive, but the Commissioners consider, from the evidence before them, that it might fairly be assumed that a depth of at least 4,000 ft. might be reached. This acknowledgment must give general satisfaction; for at present we have only about two mines that have reached one-half of that depth, and from the experience gained in those it appears that the high temperature is not in many cases permanent, and is frequently much modified by accidental circumstances. In this country the temperature of the earth is constant at a depth of about 50 ft., and at that depth the temperature is 50 deg. Fahr. The rate of increase in the coal districts is generally about 1 deg. Fahr. for every 60 ft. of depth. The heating process is most rapid at first, when the difference of temperature between the air and the strata is greatest, and gradually diminishes as the length of the passage is extended, never ceasing until complete assimilation of temperature. The air takes up the heat much more rapidly in pillar and stall working than in long-wall. The absorption of heat from the strata by the circulation of the air gradually lowers the temperature of a mine.

The labors of Committee C were directed to the inquiry whether there is reason to believe that coal is wasted by bad working or by carelessness, It seems that the extension of the long-wall system has diminished waste, but much is still lost by bad working and carelessness—a very considerable amount in proportion to that which is actually used. Under favorable systems of working, the loss is about 10 per cent., while in a very large number of instances the ordinary waste and loss amounts to 40 per cent.

With regard to the quantity of coal in known coal fields, it is estimated that within depths not exceeding 4,000 ft., and after making the necessary deductions, there are (including upwards of 130,000,000 tons in Ireland) 90,207,285,398 statute tons; while below 4,000 ft., there are 7,320,840,720 tons, making 97,528,126,210 tons in all, and in this estimate no consideration has been taken of any bed of coal less than 1 ft. in thickness. To this must be added a further quantity of 56,273,000,000 tons for the probable amount of coal under Permian and other overlying formations at depths of less than 4,000 ft., and, deducting 40 per cent. for contigencies, giving an aggregate of 146,480,000,000 tons. Estimating a gradual increase in the population, and that the consumption per head of population will attain its maximum at the end of the present century, a total consumption is shown of 146,736,000,000 tons in 360 years, so that about Christmas, 2231, we shall have to look for our supply of coal from the sub-Permian deposits at a depth below 4,000 ft. The Commissioners admit that every hypothesis must be purely speculative, but that if the present rate of increase in the consumption of coal be indefinitely continued, even in an approximate degree, the progress toward the exhaustion of our coal will be very rapid.

The caisson for the New York pier of the East River Bridge has been towed safely to its position.

THE HEMATITE ORE AND IRON OF CUMBERLAND.

From "Engineering."

The famous hematite ores and pig irons produced in that narrow strip of North Lancashire which runs into Cumberland are generally colloquially included with those of West Cumberland itself. We have followed this fashion in the above title, though the important works we describe elsewhere, as several others of those hematite districts proper, are situated in Lancashire. Then we could not well talk of *the* hematite district, as hematite iron ore is found in other parts of the United Kingdom. This custom of speaking of hematite iron, as if it came from West Cumberland only, is no doubt due to the fact that it was first produced near Whitehaven, in that county. So late as 1856 only one ironworks, that of the Whitehaven Hematite Iron Company, was producing hematite pig. It is to this establishment, therefore, that is due the credit of proving the productibility of a first-class pig iron from hematite ores alone by the use of coke; and their iron, termed "Cleator Moor," from the name of the place, near Whitehaven, where it is made, is of course very well known indeed. They then possessed three blast furnaces solely using the ore of the district. Since the demonstration of the Bessemer process, other competing works have rapidly risen up at the bidding of its magic wand; and the following may be looked upon as a complete list. The works at present in existence are beginning with the first established:—The Whitehaven Hematite Iron Company, making at Cleator, near Whitehaven, with 6 furnaces, the pig iron of that name; then for size, the Barrow Iron and Steel Company (Limited), at Barrow-in-Furness, 14 furnaces, with the Duke of Devonshire as chairman; the Furness Iron and Steel Company (Limited), with 2 furnaces in blast and another nearly finished, whose works we are describing; the West Cumberland Hematite Iron Company (Limited), 5 furnaces at Workington; the Millom Hematite Iron Company, 5 furnaces, at Millom — a small place on the other and northern side of the river Duddon, nearly opposite the Furness Works; the Maryport Hematite Iron Company of Maryport, 7 furnaces; the Solway Hematite Comany (Limited), 3 furnaces, also at Maryport, and adjoining those of that name; the Workington Iron Company (Limited), 6 furnaces, of Workington, who also convert their own pig iron; Messrs. Bain, Blair & Patterson, of Harrington, 4 furnaces; and the Carnforth Ironworks, 5 furnaces, not very far from Askam itself. To be soon at work are two new companies — the Lonsdale Hematite Iron Company, situated near Whitehaven; and the Moss Bay Hematite Iron Company, near Workington.

Now the whole of this so important iron district, with its portentously sudden growth; with its port of Barrow-in-Furness increased some twenty-five fold within the last ten years; with the fabulous fortunes—in some instances incomes of from £40,000 to £50,000 per annum —that have already resulted to the fortunate original lords of the mines; with its numerous works and innumerable pits that threaten to turn the loveliest district in England into another Black Country; with a production risen from 225,000 tons in 1854 to 1,047,819 tons in 1869; with this production augmented in 1870, and daily rising; represent neither more nor less than the simple chemical fact that good iron, and still less good steel, cannot be produced from pig containing phosphorus—more especially if that steel be produced by the Bessemer process. Day by day experience has shown that, for some reason or other—for science has not yet discovered any reason, though she has helped to remedies—a little excess of phosphorus in the composition of iron destroys its structural value. From two to three thousandths per cent. of phosphorus have little influence on iron; seven thousandths per cent. make it brittle or cold short; so that the prosperity of this hematite district may be said to be mainly a result of this difference.

A minor, but still important, qualification is the situation of the ore along a line of coast studded with fine harbors. Running the eye up the coast line, stopping at the magnificent Solway Firth, closely skirted by the railway, one sees in succession Barrow-in-Furness, Raven-

glass, Whitehaven, Workington, Maryport. The situation of these hematite beds, with the works growing out of them, is, in fact, exceptionally splendid. Already, before the late rapidly increasing demand for hematite pig to be used in the Bessemer steel-works of England, and for mixture with the spathic ore pig of the Westphalian steel works, or the French pig irons smelted from the ores of Corsica, Elba, and Algeria, most of the ore produced was shipped to the iron-works of Staffordshire, South Wales, and of Scotland, where considerable quantities were also used for "fettling" the puddling furnaces.

Much pig iron for the time, was already made at Ulverstone during the latter part of the last century—of course with charcoal—the Back Barrow bar iron being held in as good esteem as Swedish by the Sheffield steel converters. Going back to yet earlier times, we find authentic records that these ores were worked in the middle ages; and there is also very strong evidence that the Romans, who seem to had a marvellously keen faculty for exploration, had iron mines in West Cumberland. There can thus be no doubt that the ores of Cumberland have been worked from immemorial times; and that the iron they produced has served for many an old knight's elaborate suit of that armor, a glance at the relics of which shows what good smiths and fitters they must have had in those days.

As in Westphalia, these hematite beds are mostly found in the carboniferous limestone. To the careless eye they would appear of almost boundless extent, but the true reason of this is their irregular diffusion, not in veins, but in so-called "pots" or pockets, also in hollows, and but seldom in the form of true veins. The first question is, how these hollows were made in the limestone. This appears to have, in many instances, occurred by means of the erosive action of water; as the sides of the hollows are generally marked or striated as if by its flow. Smooth faces, exhibiting such striæ, often intersect the mass of iron ore near its boundary, also proving the fact of settlement or disturbances. The hollow being once formed, then comes the more difficult inquiry as to how, or at least when, they were filled. Strong reasons have been given for supposing that these ore deposits originated during the carboniferous epoch, and have been deposited in the erosions of the mountain limestone in most cases, or, as in others, interstratified in regular beds like coal seams. Fossils of well-known plants of the coal measures have also been discovered metallized into hematite iron in a similar way as coal plants are found turned into the carbonate of the protoxide or the bisulphide of iron or carbonate of lime. The ligneous structure of the plant has often formed the mould, so to say, for injections of peroxide of iron. These observations bear more especially upon the deposits of ore of the Furness district of North Lancashire. Near Whitehaven, in Cumberland, there are true veins of hematite occurring in the older slates, porphyries and syenites, as at Black Comb, Dent Fell, and Ravenglass. In the Cleator district, near Whitehaven, a narrow band of limestone on the clay slate curves round the flank of Dent Fell; and most of the mines of the Whitehaven district are found here. It is near the Red Pike mountain that iron is believed to have been smelted in the time of the Romans. But, on the whole, it may be held that the exact geological position of hematite ore is not very definite. There are two principal sorts of hematite worked in the district, locally designated as "hard" and "soft." More particularized, we find four kinds:—(1) A very dense massive form, with a conchoidal fracture and a dense blue color; (2) mammellated concretions, termed in the district "kidney" ore, showing when broken a fibrous, silky lustre, and a blueish, steel gray color; (3) a very soft variety, which may be rubbed between the fingers; (4) specular iron in small crystals of a six-sided rhombohedral form.

Hematite ore is found in several other districts in Britain, but seldom, if ever, so free from phosphorus and sulphur as in the hematite districts *par excellence* of North Lancashire and Cumberland. Near Cardiff, for instance, the hematite found there contains more than one per cent. of phosphoric acid, and still more sulphur. The hematite of Lantrissant, Glamorganshire, contains rather less impurity—from about one-tenth per cent. phosphoric acid, and nearly four times as much sulphur. The chemical character of the West Cumberland ore is generally that of nearly pure anhydrous sesquioxide of iron. It is, how-

ever, mostly mixed with very minute traces of lead, cobalt, tin, arsenic, and even of sulphur; and also of manganese, alumina, lime, and magnesia. The distinguishing features of most of these ores is the presence of a considerable proportion of silica, and the absence of manganese. The almost entire absence of manganese in the hematites of Cumberland and North Lancashire cannot be accepted as evidence that this adjunct is not indispensable for the Bessemer process. The converter charges at Sheffield, in Westphalia, and Styria, are not merely dosed with *spiegeleisen* at the end of the operation, but are also mixed with a proportion of Forest of Dean or Swedish or Westphalian pig iron respectively. But these characteristics may not improbably account for the somewhat red-short quality of malleable iron *puddled* from Cumberland pig. In this process, manganese, which apparently has the power of removing silicium from iron, is not generally used. But the high temperature required, according to strong evidence, by the manganese for exercising this power, is certainly present in the Bessemer converter, and just at the end of the process, when the spiegeleisen is poured in. Generally the iron made from the West Cumberland hematites has the reputation of being very red-short when other kinds of pigs are not employed; still we know that 5-ton "blows" of first-class steel are made from a composition of which nearly 100 cwt., or five tons, consists of three different kinds of Cumberland hematite, with admixtures of only 10 cwt. of Swedish pig and 15 cwt. of Forest of Dean.

An analysis made at Konigshütte in Prussia, of Barrow hematite, afforded 4.50 per cent. of silicium, 3.3 graphite, 0.08 combined carbon, 0.04 phosphorus, 0.09 sulphur, and 0.57 manganese. This gives a somewhat lower character, as regards purity, at any rate to Barrow pig iron; while the proportion of manganese is unusually high. From a different source we have an analysis of gray pig No. 2, smelted with coke at Hochdahl, in Siegen, which gives 1.81 per cent. silicium, 3.39 graphite, 1.07 combined carbon, 1.08 manganese, 0.043 sulphur; 0.006 phosphorus—the difference being iron. There is no doubt that a little phosphorus is always present even in Bessemer steel converted from the best brands. We know that, in the course of hundreds of blowings carefully investigated by spectrum analysis, the sulphur and phosphorus lines were never absent. But—and this is just the weakness of spectrum analysis — these determinations were simply qualitative, not quantitative. We all know how good is Krupp's steel, and according to analysis by Mr. Abel, of Woolwich, it contains as much as 0.02 of phosphorus, 1.18 combined carbon, 0.33 silicon, no sulphur, a trace of manganese, 0.12 cobalt and nickel, and 0.30 copper.

We are not of the opinion, held by some, that it is probable that the iron industry of Cumberland will ever expand to the extent of that of the Cleveland district. The indispensable element of cheap production is wanting. In the first place, the pure blast furnace coke required has to be fetched from the Durham ovens, which involves a not inconsiderable freight for an article in large demand already. The coke used has to be as much as possible chemically free from sulphur, and to be in large pieces for the passage of the blast—already somewhat difficult on account of the small size of the ore. It is possible that progress in washing and coking the inferior coal found nearer than Durham may make some change, but this has not yet taken place. Then the ore is not found so regularly and in such quantities as might be desired. The best proof of this is to be found in the fact that the royalties on the ore have risen from 1s. 6d. to 3s., and even to as much as 5s. 4d. per ton. In the Cleveland district they are never more than from 4d. to 8d. The price of the hematite ore itself has risen 7s. per ton above what it was 12 months ago. This may possibly be somewhat due to the undoubted revival of trade now taking place; but, in any case, as the Cumberland ore lies far away from sulphur free fuel, pig for steel making will never be made at much less than 70s. per ton. The prices are now much higher.

THE "Scientific American" says that the total area of the known or explored coal-fields in the civilized world, independent of the American coal-fields, are less than 20,000 sq. miles. When compared with the immense areas and extent of the latter, how small and insignificant the former appears.

CRITICAL EXAMINATION OF THE IDEAS OF INERTIA AND GRAVITATION.

By JAMES D. WHELPLEY.

1. NATURAL LAW OF GRAVITATION.

Astronomy, as a true science, was founded upon Kepler's discoveries of the elliptical form of planetary orbits, and the law of equable areas. This law is based upon the facts discovered by Kepler, that the orbitual velocity of planetary bodies increases or diminishes in a simple ratio as they approach or recede from the solar centre. Newton, in view of Kepler's observations, introduced the idea of a *nexus* of force, binding together all the numbers of the solar system by a mutual gravitation.

It was thought proper by its discoverer to assume that the intensity of this force should vary inversely as the square of the distance between the gravitating masses. By this it would be found always in a correct mathematical relation with planetary distances and velocities, and would always counterpoise the tangential force.

Although the Newtonian formula for the radial tendencies of the planets, in counterpoise with the tangential, is found to be correct in the method of its use, as a formula of calculation, it is nevertheless demonstrable that this formula does not represent the intensity of gravitation, but is in fact a mathematical expression for the rate of variation of the falling force, or radial motivity, of planetary masses, in reference to the solar centre. In other words, it expresses the initial motor force of planets drawn in their orbit towards the sun.

Assuming that the radial and tangential forces are effects of independent causes, then the radial force in a *circular* orbit is a constant; a steady pressure, always equal to it itself, holding the planet against the action of the tangent force at an invariable distance from the sun. It is then a pressure acting with a constant velocity through equal spaces in equal times, and is represented by the formula, *pressure* × *velocity* × *distance moved through*, or p. × 1 × 1, for the first unit of distance of the planet from the sun. At one-half of that distance, velocity, by Kepler's law, being inversely as distance, the second term of the formula (velocity) = 2. If we now assume that the force of gravity varies, like the velocity, *inversely as the distance*, we shall have 2 p. × 2 × 1 = 4 = radial motor or inertial force at one-half of the same distance from the sun.

Let the velocities, at successive distances, be represented by the series 1, 2, 3, 4, 5, etc., inversely as distance. Let the cause of these velocities, that is to say, the actuating force of gravity, be represented in its degrees by a similar series, also inversely as the distance, in a simple ratio; then, the time being always unity, a multiplication of each member of one series by the corresponding one of the other gives 1^2, 2^2, 3^2, 4^2, 5^2, etc., as a third inverse series expressing the diminution of radial motor force, or tendency toward the sun, at increasing distances. Although these numbers are the same with the Newtonian formula of the distance square inverse, they do not express the intensity of the gravitating force, but only a result of intensity evolving a motor force through the intervention of velocity.

Since it is thus demonstrable, by exact reasoning and deduction, that the pressure of gravitation does *not* vary as the distance *square* inverse, but simply as distance inverse, it has been necessary to reconsider the theory of this force and of mechanical power in general as dependent upon it, the place of the hypothesis of Newton being vacated.

Because all bodies falling freely near the earth are associated with it in movement by the law of gravitation, and move in elliptical orbits determined by terrestrial *foci*, the motor force of such bodies will be represented by the same formula that expresses the law of the radial tendency of the planets.

Thus, in the instance of a cannot shot, setting aside the resistance of the air, the trajectory would be elliptical, and in no respect different in nature from that of a comet. The impulse of the explosion communicated to the ball would evolve the tangent force, and gravity the radial.

Any mass of matter in orbitual motion has attained its velocity by degrees, from a point of rest, under the action of an accelerating force, either constant or variable; but in either case the tangent

movement of a projectile or of a planet is subject to the same laws of acceleration or diminution that govern a fallen body. Its momentum will vary as vel.^{2}, and we have seen already that this formula is a component of two equal elements, the actuating force or pressure (p.) and the space passed through in a given time (v.) *If the actuating force varies, the velocity varies in the same degree.* Hence the motor value, when mass and time are constant, varies as vel.^{2} in all cases of momentum. But this mathematical expression (vel.^{2}), has no value in a philosophical sense, and does not express the nature of motor force.

The motor force of a mass accelerated under a constant following pressure like the force of gravity, will increase in the degree that it passes through or occupies space. When it has attained a relative velocity of 10, *e. g.*, it will have fallen through 100 cubical units of space, and will have acquired 100 units of motivity.

The space occupied during the increase of its motion from rest, by a mass free to move and subject to an accelerating pressure, is the measure of the motivity which it has acquired.

Space is occupied by force in at least two modes, by volume, and by position and linear motion. The expansion and contraction of gases under the influence of heat and cold illustrates the development of forces, and their measure, in the occupation of space by volume. Movement through space, represented by the successive cubic units occupied in a given time, illustrates the second mode. *The force of inertia, on the other hand, is the occupation of a position in relation to other bodies.*

It is not possible to ascribe a dynamical value to the abstract idea of empty space, or of motion through it ; but when it is remembered that the position of a body in space, and its volume, belong to it by virtue of a forcible relation with other matter, it will be seen that any change of these can be brought about only through change of such relations. In other words, the space passed through, under the described conditions, measures the quantity of motion transferred to the vibrating substance of the moving mass. But it is necessary to discuss other points before entering fully upon this.

A body moving freely unde the gravitating force must have attained its velocity by increment or decrement, under the natural law of the evolution of motor force. A planet approaching the sun has its motor force augmented by a gravity of which the intensity increases as the distance diminishes, and an increase of velocity consequent thereon in equal ratio. One component is the simple increase of the actuating force ; the other measures itself by the larger space traversed because of that increase, marking the rapidity with which the pressure or actuating force is absorbed or communicated.

2. NATURAL LAW OF INERTIA.

If two masses are in gravitant relation they move relatively to one another ; but if the matter of one of them happens to be distributed about the other in a shell, at any distance, there can be no reciprocal movement, and this is a necessary deduction from the observed facts of gravitation. But we cannot suppose that the dynamic relation which we find everywhere existing between the particles of matter is cancelled by any particular form of distribution ; it has, on the contrary, the same value, but with a different effect. Matter at the centre of the earth can have no "weight," being equally influenced on all sides by the mass of the earth ; but we are not therefore to infer that *because there is no direction in which it can fall*, this central matter does not evolve dynamical effects equal to the full results of the superior influence of the earth as we approach its centre.

The weight of a terrestrial body being only its initial tendency toward the centre, there are many ways in which it may be masked and yet not diminished. Bodies floated or supported by air or water, or by centrifugal force, or by counterpoise on the two arms of a balance, etc., are examples of a masking or disappearance of "weight" or initial motivity toward the earth's centre, and of the appearance in its stead of *inertial* force, such bodies resisting all attempts to move them *in any direction*, whether toward or from the centre, with a force called "inertia," and which is measured by gravity ; for in estimating inertia we begin with the element of "weight" as with its original.

Weight being a motor force is compounded, like other forms of evolved force, of a fixed number of elements. The

weight of the earth pressing toward the sun in its orbit, or a weight turning the scale of a balance, are compounded alike of the quantity of matter, the intensity of gravitation, the velocity of motion, and the duration of the movement, and of the first and last are taken as units; weight varies as the intensity of gravity multiplied into the velocity of movement in the direction of the force.

The effects of the gravitating masses upon each other are found to be such, that any two masses in space at an appreciable distance, free of all obstruction, will move always in parallel and opposite directions, with velocities inversely as their masses, and with equal forces. The earth and the sun are relatively "floated" on the orbit, and their mutual "weight" is masked, taking the form of *inertia* and of momentum.

It is a fact of common experience that a particle of matter, whatever may be its condition or dimension, retains for itself a certain bulk or volume of space, which is proper to it, and is variable only within measurable limits; and also a certain position in space *in regard to other bodies*. But neither of these properties can appear or be evolved, except by virtue of relations with other matter. The volume of a mass or particle is made evident by pressure; it limits the approach of other bodies. The position of a mass is manifested as to its strength by the *time* it occupies in yielding to a definite and constant pressure, and this is called its *inertia*.

What is true of the mass must be true of the ultimate particle. A single atom of matter, the only one in existence, would evolve neither weight nor inertia, but give it a companion, it would have both. Let now a vast number of atoms co-operate in evolving the qualities of weight and inertia in a single particle; it will be seen that these qualities grow or diminish by relation.

The force with which the earth holds its position in space is due to its relations, first, with its own component atoms, an accumulation of atomic influences by the reciprocity of which terrestrial inertia and gravity is evolved and determined. Second, its relations with the sun, which communicates to it an inertial force $\frac{1}{1600}$ as great as its proper gravity. Finally, the influence of the moon, and of the planets, and of the cosmical system of dark and bright bodies, must be counted among the causes of the earth's inertia.

Common experience measures the degree in which masses of matter resist pressure by their weights. Gravity, whether it be equipoised or not, producing either relative motion or relative rest, is the measure of inertia, and the force with which the earth resists the perturbing influence of another planet is generated not only by its relation with its own component parts, but with every particle of matter in the universe.

This is the natural idea of inertia drawn from common experience, and in the most recent works of the great scientists inertia is made the converse of momentum, momentum being measured by the time required, with a given pressure, to bring a moving body to rest, and inertia with an equal pressure to restore its original velocity.

The ideas of inertia and momentum adopted by Newton, and made the basis of his system, are entirely different from those of modern writers.

Newton's best expounder, Maclaurin, defines inertia to be a constant property of bodies by which they remain at rest for ever, unless compelled by an external force, and continue always in motion in a right line with their last acquired velocity and direction, unless checked or accelerated by an external force. Inertia in the Newtonian system was a constant, and determined the "quantity of matter in a mass." Momentum was measured by multiplying velocity of motion into quantity of matter moved, that is to say, multiplying inertia by velocity.

These ideas are no longer available for use in mechanical philosophy, motion and rest of bodies being known by common experience to be always and presently determined by external relations.

Newton was obliged to assume that inertia, "the force which resists gravitation," is invariable, because he made the intensity of the gravitating influence to vary as the distance square inverse, an hypothesis which, as we have seen, does not express a natural truth.

3.—RELATION OF PLANETARY INERTIA TO GRAVITATION.

A falling body near the surface of the earth does not begin to fall at the mathe-

matical instant its support is removed. The movement is not only not mathematically instantaneous, time being required for propagating motion in matter, but the increments of motion in falling are equal, definite, and require a precise expenditure of time. The rate of acceleration varies with the intensity of gravitation, being less at the equator and more at the poles, less on the summit of a mountain, and again less as we descend beneath the surface of the earth. The velocity of acceleration, being determined by the intensity of gravitation, diminishes in the direct and simple ratio of the distance from the centre of the earth, above the surface, the earth's semi-diameter being taken as the unit of distance.

The most noticeable and material fact in the phenomena of falling bodies is their resistance to any acceleration by downward pressure. The fall of a body toward the earth can only be hastened by a downward pressure *added* to that of gravity. The falling is at a fixed rate of speed and acceleration, which must not vary except under known laws of distance and mass. The resistance offered by a falling body to a force urging it downward in excess of its natural rate of falling, is the same inertia that resists the motive force of gravity, or any other external motive force. *But this inertial force for a given mass is also determined by the intensity of gravitation, and this again by distance.* Let two plummets hang side by side. They are drawn toward each other by a measurable force of gravity, as much less than the force which draws them toward the earth as their *mass* is less than that of the earth. The earth may draw them with the force of a pound weight each. They draw each other with a force many billions smaller ; the inertia of a mass at the surface of the earth is determined by its mutual gravitative relations with the earth. But the inertia determines the density, and density, other things being the same, is the measure of gravity. The degree with which the two plummets attract each other will consequently vary with the earth's influence ; it will be less, for example, at the summit of a mountain than at the level of the sea.

The motion of falling bodies must be produced by some simple and invariable cause common to all kinds of matter under all conditions. The first effect of the earth's mass upon a body is to give it a certain degree of immobility, which is the base of inertia. The second and subordinate effect is a movement with a definite and constant acceleration, the inertia being not affected by this movement, but always the same at equal distances from the earth's centre.

We know of no masses moving in space that move by their inertia ; they are all, as far as observation takes us, controlled and urged by the effect of gravitation.

4.—NATURAL CAUSE OF THE MOTION OF FALLING BODIES.

Since inertia never of itself produces motion, and is nevertheless the first effect of masses upon each other, some other conditions must be found in which inertia is an element, to account for the motion of falling bodies.

Let us imagine two homogeneous spheres of some definite size, substance, and density, differing from each other only in that they occupy different positions in space. The two spheres are mutually impenetrable and individualized, but exactly in the same manner and degree ; they discover no differences except those of position ; but this also implies that the units of matter that compose them are severally at unequal distances, and this simply because each has a place and volume of its own.

Every day experience bears testimony to a fact which is also supported by the most refined analysis, that rest or quiescence is a result of the balance of forces, and motion, of their inequalities. This condition being universal, it must be true that the motion of falling bodies must be a result of unequal pressures. Between the two spheres that we have been considering, there is but one possible inequality, and that is determined by the nature of space itself, and of matter as its occupant. The two spheres, being free to move in space, will, as experience testifies, move in relation to each other. But because all motion arises upon an inequality of forces, and since none other can be discovered, save the unequal distances of the parts of the two spheres, the natural cause of falling or gravitating must be looked for within this difference, and not elsewhere.

A mass equally influenced on all sides by gravity, as at the earth's centre, or in

a hollow sphere, would not have motion. Inertia is equal in all directions, varying only with distance and quantity. Between every pair of separated molecules, because each of them has position and volume, there is the inequality. The first effect of the two particles must be to assign each other position in space; and because their power of doing this diminishes with distance, it follows, that between any two masses, the parts of each that are nearer will affect each other more powerfully than those that are more removed; and this inequality determines a movement in the direction of the greater force.

5.—RELATION OF MASS AND DISTANCE.

The "weight" of the earth increases as it approaches the sun. The elements of the weight are the intensity of gravitation and velocity of fall; which, when multiplied into each other, give the expression for radial motivity. The first element, intensity of gravitation, is the same with an increase of inertial value or immobility of each particle composing it, and an immediate consequence of *this* increase is the augmentation, in the same ratio, of "gravity," the first element of motivity. If the quantity of matter in the sun were doubled, the effect would be the same upon the earth as though it were at only half distance from the sun. Each of its particles would have a double inertia and a double gravitating force. The velocity of fall would increase in the same ratio, and the radial motivity would be quadrupled.

Increasing the quantity of matter in the solar centre would augment the radial motor or falling force in the duplicate ratio of that increase.

If the earth had been drawn toward the sun with one unit of velocity and one of gravitating influence, were the mass of the sun doubled, it would fall in the orbit with two units of each of those elements, and the multiplication of these would give four times the motivity, etc. The inertial element, or force of position, is doubled, and the solar tendency must be doubled in consequence. Increase of the solar mass has, then, the effect upon a planet of a nearer approach to the sun, and when the effects are the same the causes must be. Increase of the number of material units composing the mass is the same, in effect, with diminution of the number of units of distance. The effect of both is to increase the dynamical force of the planet in a simple ratio, force of position (the basis of inertia) first, and gravity in the same degree.

6.—MOTOR FORCE EVOLVED BY INDUCTION.

In the case of A and B—two unequal masses gravitating mutually in space—it is first evident that, as in terrestrial gravity, each has an action upon itself, creating a "proper" inertia. Let the force of position evolved in A be to that of B as 1 to 10. Then A being the unit of a mutual force, which is independent of the individual or self-determined gravitations of A and of B, each unit of B is in gravitating relation with A, *by which A acquires* 10 *units of communicated force.* A, on the other hand, communicates one unit of the same force to each member of B. Then, A, having 10 units of force, will have 10 of initial velocity or weight in relation to B; and, because the multiplication of the two gives the momentum, A will have 100 motor units. But B has for each unit only *one* of velocity; the momentum of its mass is then apparently $1 \times 10 = 10$. Which is untrue.

For we learn by observation, that the velocity of B being 1, its motor force will be 100, equal to that of A. It follows from this, that the force *evolved* in B is not 10 but $100 : 1 \times 100 = 100 =$ motor force of B and of A. There is no possible mode of explaining this difference, but by assuming that the evolution of force in B is as the square of the number of its units, or as $10 \times 10 = 10^2$. But by the same rule the evolution of force in A should also be *as the square of the number of the units of force evolved in it.* Which is true.

If velocity—a mathematical expression for relative rate of motion through space—were a force itself, and not merely an index of the rate of evolution of forms, it would be philosophically correct to say that the motor force of A is as the number of units of force evolved in it by the action of each unit of B ($= 10$) multiplied by the velocity consequent on such evolution: $10 \times 10 = 100 =$ motivity of A = motivity of B. But if we regard velocity as what it is, namely, *the index of the rate of evolution,* then the velocity of A really indicates the evolution in itself of 10 additional units of force for each one of the original units of gravitation. But $10 \times 10 = 100 =$ motor force of A = motor force

of B. Hence the *motor force of any two masses in mutual gravitation will be as the square of the number of units of evolved force in either.* It has become evident that velocity must be regarded only as a result, and not as a cause, of the evolution of forces. And the same is true of motion in general, which is always a result of dynamic inequalities.

If the above reasonings are correct, mechanical motor force is inductive, and no mass of matter can be influenced by gravity without communicating this effect inductively to all bodies within its influence.

GUNS VERSUS TARGETS.

From "The Engineer."

"The Woolwich Infant," otherwise Mr. Fraser's 35-ton gun, has just been bored out fron 11.6 in. to a diameter of 12 in. From some inscrutable reason, it refused to burn all the powder which it was desirable to burn. Better results are expected now, because the charge will occupy less length of chase. The trials will not be made, however, for some weeks. Meanwhile the Woolwich gun factories are not idle. Whether the 35-ton gun will or will not burn 120 lbs. of powder, it is certain that it is or can be made by certain modifications in the gun, the projectile, and the powder, the most powerful weapon in existence. Col. Campbell hopes to have ready by January, thirteen 35-ton guns, eighteen 25-ton guns, one hundred 18-ton guns, and a host of smaller fry. This is pretty well for a year's work. There is no other nation capable of doing so much, if we consider that, thanks to Mr. Fraser, all these guns will be sound and reliable weapons, fit for the worst vicissitudes of warfare. Recent experiments at Shoeburyness have led us to conclude that of late the guns are having much the best of the battle which has so long been waged between them and armor plates. It is doubtful if better plates can be made than are made now. They may be punched by shot and shell, pounded by all kinds of guns and all kinds of projectiles, but they no longer crack and split to pieces. They behave like copper. It is, indeed, just possible that we have got a little too far, and that our armor plates are too ductile, and offer a less resistance to the passage of shot and shell than would a harder material. It is beyond question that circumstances might arise in actual warfare under which a plate which cracked with the impact of every heavy projectile, until it hung in scales over the structure it was intended to defend, yet kept shot and shell out, would be better than a plate which could not be broken, yet allowed projectiles to get through. In a combat, short, sharp, and decisive, the former would be the best, although under prolonged pounding—such as might take place when a fort was besieged—the latter would have the advantage. An embrasure, defended by hard plates, might be stripped in a couple of hours; but if the attack did not last more than an hour, for that hour the men behind the shield would be much safer than they could possibly be behind armor plates which could be punched by heavy shot or shell, but which could not be broken off until they had been reduced to the semblance of lace-work by a multiplicity of perforations. We know that it is generally held that a plate cannot be too ductile. The question is worth considering, however, from our point of view. If a single heavy shell finds its way into either turret, or embrasure, or ship, the chances are that the fight will be at an end as far as that turret, embrasure, or ship may be concerned. Sooner or later the gun must beat the plate, if the action be only sufficiently prolonged; but it would be a matter of little consequence how many shots a plate could stand before it fell off if it was once fairly penetrated. Every minute which could be spent in action before a projectile got through might be worth thousands of pounds, and if it were only possible to defy an enemy's guns for an hour, and if the action could be concluded in that time, it would matter little whether the shield, or the turret, or the ship's side were practically ruined at the end of sixty-one minutes. We do not wish it to be understood that we advocate the use of brittle plates. All that we maintain is, that for actual warfare that target is the best which totally prevents the entrance

of projectiles for the longest time. Half-and-half targets which cannot be broken up, but permit an occasional projectile to get in now and then from the first, will prove useless except in the case of long sieges. The first shell that gets in will destroy the gunners and dismount the gun. On shore a new crew and a new gun may be had, but this argument will not hold good at sea.

Under existing arrangements the guns have many advantages over the plates; a certain point of perfection in the manufacture of these once reached, nothing remains but to increase the thickness of the plate or to strengthen the backing. The guns, on the other hand, can not only, if time be allowed them, go on pounding the plate until it is reduced to fragments, but they can use all manner of cunningly compounded chemicals, which, put into a shell, inflict fearful injuries on the plates. We believe that the limit of perfection has been nearly reached in the plate. We are not yet even near it as regards the gun. The more experiments we try at Shoeburyness, the more conclusively is this fact proved. Our ships cannot well carry any more armor than is now packed upon them. Indeed there is reason to think that they have too much already. The question naturally arises, is there no way to dodge the shells, which by brute force, as represented by heavy plates and thick backing, we cannot keep out? It does not seem, however, that this question has ever been discussed as it deserved, and different inventors have proposed the use of elastic media, such as compressed wool, cork, india-rubber, etc., as a solution of the problem; but all these things have completely failed on trial, and probably that is the reason why so little has been attempted in the way of eluding the action of shot and shell. Let us see whether the belief that projectiles can only be kept out by heavy plates and backing, and, further, that if these will not keep them out nothing else will, is well founded.

Now, in the first place, it may be taken for granted that we do not possess a single iron-clad which cannot be penetrated at short range by the improved 35-ton, or even by the 25-ton gun. It may also be taken for granted that we cannot put on any thicker armor than we use now, unless we leave large portions of the ship unprotected, or make her of colossal proportions. Consequently we must try something else, except we are content to leave the victory with the guns. What shall the something else be? In order to answer, we must consider what actually takes place when a shot or a shell strikes a ship. If the first is of a brittle metal it breaks up in going through. The head goes on as a solid shot, followed by a shower of splinters more formidable than grape. If the shell goes through, it bursts practically just inside the plate, spreading ruin and death all round; 1 shell between decks is worse than 20 solid shot. If there were no shells, big guns would be of little use. It would be better to build ships very thin and let the shot go through them unbroken, than to provide plates just heavy enough to convert the comparatively harmless shot into mischievous grape. All our energies should be concentrated on neutralizing the effect of shells. If we can but manage this, there is little to dread from shot. Now, shells used against armor plates in the present day are fired by the concussion of the shell against the plate without fuses of any kind. A plate 3 in. thick will suffice to explode a shell. The moment explosion takes place the shell is converted into fragments, which scatter on every side according to the lines of least resistance and the direction of the initial force. For the purposes of penetration as regards the iron plates, the shell, after the explosion, is as harmless as a handful of sand. The explosion may take place at precisely the same instant that the shell is going through a plate. The latter will then hold the shell together, and the whole effect will take place inside. Bearing this in mind, let us suppose that a 4½-in. target, properly supported, is put up 200 yards in front of the 25-ton gun, and that 20 yards behind the first a second target, also of 4½-in. plate, is put up. Does any artillerist believe that it is possible to get a shell through both these plates? We venture to say, not one. The shell will explode just inside the first plate and be converted into fragments, not one of which will be able to get through the second plate. A solid shot made of steel or other very tough material will get through, no doubt, but not shell. Shells fitted with time fuses have been fired at plates, and exploded prematurely. They never did any

harm. It is, above and beyond all things, essential that the projectile which is intended to get through a plate must not break up ; if it does, farewell to penetration.

Here, then, we have the true solution of the problem : how shall we keep the shells out with armor of moderate weight? Break up the shell before it touches the armor plate. This done we have nothing to fear.

A very careful search through the official records of armor-plate experiments has failed to supply us with a single instance in which the principle we advocate has been tried. The obvious method of applying it in practice consists in using 2 armor plates, the outer one thick enough to explode the shell, and the inner one thick enough to keep out the pieces, with an intervening space, quite empty of everything but air, and of considerable width. An experiment was tried some time since, of which we can find no record, in which one plate was put thus behind the other. Solid shot, not shell, was used, and even in this case the results obtained were considered promising; but an experiment was tried still more recently at Shoeburyness, in which the target consisted of 2 heavy plates with baulks of timber intervening. In this case the shell got through, but in neither one case nor the other were the conditions precisely such as we contemplate. We admit that solid shot will not be kept out if it is tough and strong, and, therefore, we may dismiss the first experiment. In the second, the 2 plates were built up in a continuous target, one backing the other, while the timber confined the effects of the explosion of the shell, holding the latter together, so to speak, until it got through the second plate. We propose that there should be no filling in whatever between 2 plates. What is the least distance that should intervene between them, we are unable to say. We wish the authorities would conduct one or two experiments to find out. If it need not exceed 4 ft., or thereabouts, there will be no difficulty in carrying the scheme into practice.

THE INFLUENCE OF CERTAIN METALS ON THE QUALITY OF STEEL.

From "The Bureau."

We know that steel is a combination of iron and carbon, and that its hardness may be considered to be in a ratio with the proportion of carbon it contains. Nevertheless, it has been often remarked that two different kinds of steel, with the same proportion of carbon, will behave differently when worked into tools or when hardened or welded. These differences may result from different causes, such as the methods bywhich the ore and the metal have been worked, impurities in the ores, or certain metals in the ores the presence of which had been overlooked.

The metals which appear to impart valuable properties to steel are : aluminium, silicon, vanadium, manganese, chromium, tungsten, and titanium.

Aluminium and silicon, to the presence of which are attributed the qualities of the Wootz or Indian steel, have been found only in traces in the analyzed steels. They appear to increase the hardness and the fineness of the grains of the metal.

Vanadium is found in certain magnetic ores of Sweden, Maryland, and North Carolina, and in the metal extracted therefrom. Very little is known about its properties, except that the iron which contains it is generally of excellent quality.

Manganese has evidently a beneficial action—so much so that it is doubtful whether the Bessemer process would have been a success without the employment of spiegeleisen. The peroxide of manganese is generally employed by makers of crucible steel, and iron ores holding manganese are in high repute. However, steel, when analyzed, contains only traces of manganese, and the excess of this metal which has been employed would appear to form a very fluid cinder which aids in the thorough cleansing of the melted steel.

Chromium forms, according to Berthier, perfect alloys with iron and steel, and increases their hardness. It has even been said that steel may be made directly from wrought iron and chromium without carbon ; but analysis has always shown that

chromium steels contain a certain percentage of carbon.

Tungsten steel, a few years ago, was presented to the public with so much puffing that, not answering all that was claimed for it, its qualities were at once entirely denied. This was unwise. The writer had once to drill holes in a piece of cast iron which had been accidentally chilled. A dozen of drills made from different brands of the best cast steel to be found were used unsuccessfully, when a friend suggested and furnished a piece of tungsten steel. A drill made from it by the same blacksmith who forged and tempered the previous ones, went through the chilled cast iron. The last drill contained only a trace of tungsten.

Titanium is also beneficial to steel, although chemical tests fail to show more than traces of it in the analyzed steel. It imparts hardness and toughness to the metal with which it is alloyed, and a steel made from titanium ores appears to bear more heat and be harder than an ordinary steel with the same proportion of carbon.

Except chromium steel, which may contain notable proportions of chromium, the other steels have been found by analysis to contain only traces of the above-mentioned metals, which, however, are sufficient to impart valuable properties of hardness and toughness.

Cast iron, on the other hand, may contain ponderable quantities of the above metals ; but in our present state of knowledge we are unable to say whether these rare metals are combined with cast iron and steel, or simply intermixed or alloyed. That their presence is beneficial seems certain ; but how much so? and within what limits? These questions, to be answered with certainty, will require time with the work and the evidence of several experimenters, and the aid of iron-masters.

The economical method of preparing these steels is by a mixture of their ores in suitable proportions, and their subsequent smelting and treatment by the new or old processes for making steel.

TITANIUM IRON ORES.

These ores begin to attract a great deal of attention, not only on account of their abundance in certain parts of this country, but also because the metal extracted from them is very pure and tough. They seem also peculiarly adapted to the manufacture of steel, and their almost entire freedom from sulphur and phosphorus, and their refractory qualities, make them a most valuable fettling material for the puddling furnace. Indeed, the owner of a rolling-mill at Philadelphia states that they last three times as long as the magnetic ores of Lake Champlain used for the same purpose.

The steel, whether high crucible steel or low steel by the Martin-Siemens process, is of first quality, and generally harder than ordinary steel having the same amount of carbon.

These titaniferous iron ores are magnetic, sometimes with an admixture of red oxide of iron, and are accompanied by small proportions of manganese, chromium, vanadium, magnesia, lime, alumina, and silica. They are in the form of sand, as the black sand of the shores of Long Island and of the Moisie river, Canada, or in heavy compact masses which require blasting. Those of intermediary degrees of compactness are the most abundant, and require only the pick-axe and the crowbar for their mining. The accompanying rocks are metamorphic, and composed principally of the following minerals : quartz, feldspar, mica, hornblende, talc, chlorite, serpentine, etc.

The principal deposits of titaniferous iron ores in the United States are in Northern New York, Missouri, Tennessee, North Carolina, Virginia, and Maryland.

The deposits in the northwestern part of North Carolina, owned or controlled by a Philadelphia company, have been found by a recent survey to extend in almost a continuous line for over 30 miles. The deposit, which affects the form of a nearly vertical vein, has a thickness of from 4 to 10 ft. The per cent. of titanic acid varies, but is about 10 on an average. The supply of ore may be considered as inexhaustible, and charcoal is abundant everywhere. Bituminous coal-fields will be soon reached by projected railroads.

These ores have, in this country, been worked mostly in bloomary fires, and but little in blast furnaces. But as the extensive use of such ores requires the employment of blast furnaces, it may not be amiss to say a few words on the proper mode of working them.

Titanium iron ores having the reputation of being refractory, it has been

thought that they needed only a high temperature for their reduction, and consequently they have been tried in admixture with other ores in high blast furnaces, with plenty of fuel, plenty of blast, and scarcely any change in the proportions or the nature of the fluxing materials. The result was, as it should have been expected, that scaffolding and irregular working occurred.

The failure was due to three causes :

1. A too sudden change in the nature and in the proportion of the charges. We know that a blast furnace is very sensitive to sudden changes in the nature and proportion of the charges of ores, fuel and fluxes, and in the amount and pressure of blast. A regular working requires a perfect adjustment of all these conditions. Therefore, if too large a proportion of a different ore is added at once, there is no time left to properly adjust the blast, the fuel and the fluxes, and a stoppage is imminent. The more different an ore is from those usually employed, the smaller should be the proportion added at the beginning of the experiment, and there should elapse from 8 to 10 days before the proportion is increased, thus giving time to ascertain and remedy the causes of the irregularties which may take place.

2. A too long exposure to the reducing gases. In high blast furnaces, the ores are for a long time exposed to the action of reducing gases. While this arrangement is suitable for the reduction of oxide of iron, it is not so desirable for titanic acid, which, when it loses its oxygen, combines with cyanogen and nitrogen, and forms a compound which, being irreducible and infusible, may cause scaffolding.

3. A fluxing not adapted to titanic acid. Neither the composition nor the quantity of slags produced in ordinary blast furnaces is suitable for titaniferous iron ores. Titanic acid is carried away in a fusible state by the magnetic slags of the bloomary fire. But this process is too expensive for blast furnaces, on account of the great loss of metal. Therefore, since titanic acid is soluble in metallic oxides, a cheap flux containing these oxides is to be preferred, and we find them among the minerals accompanying the titanium ores, for instance ochres, hornblendic and pyraxenic rocks, and other complex silicates with metallic bases. In this case the slags are suffered to contain a notable proportion of metal.

An abundance of slag, not too easily fluid, will carry away mechanically the titanic acid mixed with it.

If we follow the example of the Swedish iron-masters who have great experience in the treatment of similar ores, we will employ by blast furnaces of medium size, high enough to thoroughly reduce the oxide of iron of the ore, but not sufficiently high to reduce all the titanic acid ; and the fluxes will be chosen and adjusted to carry away the titanic acid, whether combined with metallic oxides or mechanically, as we have just explained.

We must add that, besides the fact that titanic acid can be fused with metallic oxides, there is very little known about the relative proportions in which these combinations take place, and that their study would be as instructive and useful to the iron-master as the similar combinations of the silicic acid with metallic and earthy bases.

TESTS FOR WHITE LEAD.

The *body*, or covering power of a paint is due to two causes—a great division of the substance, which allows it to be spread over a large surface ; and opacity which allows a thin coat to impart the desired color. It is evident that a transparent substance, however finely divided, will not sufficiently color the surface over which it is spread ; and, on the other hand, an opaque color, if coarsely divided, will not cover a large area.

White lead, if formed purely of carbonate of lead, will not have sufficient covering power. The opacity of the good white lead, manufactured by the Dutch method, is due to a certain proportion of hydrated oxide of lead, mixed with the carbonate ; and we may say that the more there is of hydrated oxide in the white lead, the more body it will have.

If several samples of pure white lead are submitted to chemical analysis, those containing the greater proportion of oxide of lead, with a minimum of carbonic acid, will be found to have the greater covering power.

Our object is to indicate a rapid process by which persons not conversant with chemical manipulations may ascertain the relative body of samples of white lead, not ground in oil. This test is based on

the phenomenon presented by yellow chromate of lead, when a part of its chromic acid is removed, or, in other words, when it is made to contain an excess of oxide of lead; the yellow turns to an orange shade, which is the deeper as there is more oxide of lead uncombined with the chromic acid.

Therefore, if we put same weights of different samples of dry white lead in several saucers, and pour upon them the same volume of a solution of chromate of potassa, a reaction will take place, by which the chromic acid of the chromate of potassa will unite with the lead of the carbonate of lead, forming a chromate of lead, which will be of a deeper orange shade, as there is more free oxide of lead in the sample examined.

The solution of chromate of lead should be added in excess, that is to say, should, after stirring it with the white lead in the saucer, and allowing it to stand for a few minutes, be still of a yellow color. The samples are examined after settling, and decantation of supernatant liquor.

As yellow chromate of potassa is generally alkaline, it is better to correct this alkalinity by employing a mixture of 18 parts of yellow neutral chromate of potassa and 2 parts of bichromate of potassa, dissolved in 10 parts of water to 1 of the dry salts.

If the dry white lead is adulterated with foreign substances, the orange color will appear, but will not be so deep in tone.

This test does not apply to paints already ground in oil, in which case it is preferable to mix the weighed sample with $\frac{1}{2}$ to 1 per cent. of lamp black, and a few more drops of oil if necessary. After thoroughly mixing lamp-black and white lead with a painter's knife upon a porcelain slab or a pane of glass, the samples are compared, and the lighter the drab shade is, the greater the coloring power of the paint examined.

EXPERIMENTS AT SHOEBURYNESS.

From "Engineering."

Notwithstanding the state of perfection to which our projectiles have been brought within the last few years, that perfection is at present only relative. Our manufacturers and others have therefore been endeavoring to render it absolute, and the War Office authorities have promoted, as far as they can, the discovery of the best metal for shot. In this interest mainly, our national experimental artillery ground at Shoeburyness was again the scene of some interesting trials, which were carried out this day week. The objects were to test the value of some new 9-in. chilled shot, supplied by Mr. Unger, of the Fingspong Works, Sweden; to try some 9-in. steel shell, supplied by Messrs. Firth, of Sheffield, and some 11-in. Palliser shell. To these was also added the trial of a new picric powder for shells, which is the invention of Prof. Abel of Woolwich. The experiments commenced with the Fingspong—or as they are playfully called at Shoeburyness, the "fish-pond"—shot, fired from the 9-in. muzzle-loading gun, with charges of 43 lbs. of R. L. G. powder at 200 yards range. The gun was laid against the thin portion of the 48 ft. target, described by us last week in our article upon the previous series of experiments. This, it will be remembered, consists of an 8-in. plate, backed by 18 in. of teak, and a $\frac{3}{4}$-in. skin. The peculiarity of the Fingspong projectiles consists in their being made from a metal which is so soft that, although the head is cast in a chill, it can readily be turned afterwards. It would appear to be working out on a large scale the old experiment of shooting a candle through a deal board, for the theory of these projectiles is that they shall effect complete penetration without breaking up. This, we are informed by an impartial observer, they have done over and over again on the Continent; 10½-in. and 9-in. shot having alike readily penetrated and passed through an 8-in. armor plate, coming out whole in the rear. This, however, they certainly did not do at Shoeburyness at their recent trials.

The first shot was fired with one of these solid chilled shot weighing 253 lbs. It entered the target at an angle of 45 deg. to the face of the plate, striking it 7 ft. 6 in. from the proper right end, and 15

in. from the bottom, being 5 ft. from the line of aim. The shot, which had missed both of the velocity screens, broke up, the head remaining in the hole. The rear of the target sustaining little or no damage. The erratic course of this shot was attributed partially to the gun being cold, no scaling charge having been fired, and partially to the softness of the studs. Round No. 2 was therefore a repeat of No. 1, the projectile striking the target at a point 3 ft. 1 in. from the right proper end, and 5 in. from the top of the lower plate, being a deviation of 2 ft. 7 in. from the point aimed at. The shot effected total penetration, in which it was assisted by a previous shot hole, passing out in the rear through a smith's shop—which was, of course, empty—and breaking up. The point and several large fragments were found in the tramway some 50 yards to the rear of the target. A 9-in. Firth's steel shell, weighing 241 lbs., and filled with a bursting charge of 7¾ lbs. of powder, was then fired from the same gun. The projectile this time cleared the target altogether, passing over the top, and burying itself in the earth roof of an old casemate several yards to the rear without exploding. This result rendered it apparent that either the shot did not centre in the gun, or that the platform was not steady, and that the deviations of the Fingspong projectiles were due more to defects in the piece or platform than to softness in the metal of the studs.

At this stage the proceedings were varied by Col. Milward, who directed the trial of the picric powder to be made. This powder is of a bright yellow color, and is prepared from carbolic acid. Mr. Abel places it, as regards explosive effect, half way between gunpowder and gun-cotton. He states that it does not act injuriously on the metal of a gun when fired from it, and although not at present fitted for that use, a modification may hereafter be found which will answer the purpose. The first round, No. 4, in the consecutive order, was with a 9 in. large core Palliser shot, having a bursting charge of 4 lbs. of gunpowder in order to afford a comparison with the picric powder. The gun charge was 43 lbs. of R. L. G. powder as before, and the range 200 yards, the gun being laid against the thick portion of the target, which is composed of an 8-in. plate, 6 in. of teak a 5-in. plate, 6 in. of teak, and a 1½-in. skin. The shot struck the lower plate 12 in. from the bottom and 4 ft. from the proper left end, effecting a penetration of 18.2 in. and bursting in the hole. The rear part of the shell was blown to the front, some of the fragments of the base flying back nearly to the gun. The next round was fired under precisely similar conditions to the last, with the exception that the bursting charge of the shell was 4 lbs. of picric powder. The results also were very similar, the shot striking the same plate 3 ft. 4 in. from the proper left, and 2 ft. 4 in. from the base. The head remained in the hole, effecting a total penetration of 17.5 in., the rear of the projectile and some of the picric powder being blown to the front. No conclusion could be arrived at from these two shots as to the relative values of picric powder and gunpowder, as the shots did not penetrate sufficiently far into the target for the charges to have any lateral effect upon the structure. It is probable that the charges were too sensitive, and burst a little too soon, thereby preventing further penetration of the shot. No doubt, by retarding explosion, the projectile would have a better penetration, and the burst would take place at the right moment with better effect. Be this as it may, we have at present no data whereon to base an estimate of the value of picric powder as a charge for shells.

The order of the programme was then resumed, and round No. 6 was a repeat of No. 3, rendered necessary by Firth's shell in the former round flying over the target. In the present case the shot grazed the ground 18 ft. from the face of the target, ricochetting on to the plate, there making an indent 15½ in. long by 9 in. wide, and 3 in. deep, and breaking up. This result rendered another repeat necessary, and the projectile in No. 7 round struck the upper plate of the thin part of the target 12 ft. 7 in. from the proper right end, and 2 ft. 8 in. from the bottom of the plate. The shell burst in the wood backing, the point of the head projecting several inches through the rear skin. Although a considerable amount of damage was done to the rear, it is certain that that damage would have been much greater had the explosion been slightly retarded. A return was then made to the Fingspong metal, a cored—or rather a bored—shot being directed against the thin portion of the target. It struck the upper plate 11

ft. 9 in. from the proper right end, near the upper edge of the plate, and 2 ft. 9 in. from the line of fire, entering at an upward angle of about 45 deg. A penetration of about 12 in. was effected, the point remaining intact, but rebounding, with a large portion of the body attached to it, 5 ft. to the front. The projectile—so much as remained of it in one piece—was much cracked longitudinally, and was afterwards broken up by about a dozen blows from a heavy sledge hammer. This round decided the fate of the Fingspong projectiles, which, although made of splendid metal, did not in these samples reach the standard of the chilled projectiles at present turned out at Woolwich. The 9th round was with a 9-in. Firth's steel shell carrying a bursting charge of 7 lbs. 6 oz. of powder in two bags. The shell struck the thin portion of the target 1 ft. 7 in. from the proper left of the upper plate, and 1 ft. 9 in. from the top, bursting in the wood backing, which it set on fire, and doing considerable damage to the rear portion of the structure. A heavy piece of the shell was thrown to the rear of the target, which bore witness to the great destructive effects of the projectile, the teak backing having a large hole blown upwards above the point of explosion, opening to the top of the works. In the last few rounds with the 9 in. gun, the shots were delivered well on to the points of aim, so that the gun appeared to have warmed to its work, although the earlier shots were much more wild than, under the circumstances, they ought to have been. The fouling of the gun probably aided in insuring the correctness of the latter results.

The splendid 11-in. Woolwich gun was then brought into play with a Palliser shell filled with a bursting charge of 9 lbs. of powder. The gun was laid to the thick portion of the target at 200 yards range, and was fired with a charge of 85 lbs. of pebble powder. The projectile had a velocity of 1,262 ft., and struck the lower plate 18 in. from the top edge, and 3 ft. 6 in. from the proper right end. It passed clean through, bursting splendidly in the wood backing, and yet the base plug and portions of the shell were driven through far to the rear. In the 11th and final round, the gun charge was reduced to 75 lbs. of pebble powder, and a Palliser cored shot charged with 6 lbs. of powder. The velocity was 1,187 ft., and the projectile struck the upper plate of the thick portion of the target 16.5 in. from the bottom edge, and 19 ft. from the proper left end of the plate. The shell went clean through the target, bursting apparently in its passage through the skin. The results were eminently satisfactory, and fully maintained the character of this excellent weapon and of the projectiles.

The results of the day's proceedings served to establish three things mainly: Firstly, the inferiority of the Fingspong projectiles to those turned out at Woolwich; secondly, the exceptionally fine character for the Firth steel shells; and thirdly, the subjection of the targets to the guns once more. There is one thing to be said for the 11-in. gun, and that is that it is properly mounted on an iron carriage and slide, which its 9-in. companion is not. This may in some measure account for the wild shooting of the latter at first. But, however this may be, it is to be hoped that steps may be taken to insure a proper mount for every experimental gun, so that fair and accurate results may be obtained. It is a curious fact that the 11-in. gun has been greatly decried in the past; no one appeared to have any confidence in it, notwithstanding that a number of Blakely guns of that calibre were made years since, and have done good service in Peru. But now that the 11-in. gun has asserted its position, it is very probable that a strong tide of military opinion will set in, in its favor.

The manufacture of casks is carried on on a large scale at Gallipoli, and in the 5 principal manufactories in that town it gives employment to upwards of 400 persons. The casks made at Gallipoli are in great demand throughout the Mediterranean, as from their excellent construction they are adapted for containing oil. During the past year (1869), besides those required for the exportation of 29,664 salmas of oil from this port, 92,428 salmas of empty casks were exported to the following places by 125 vessels:—To the Italian ports, 42,727 salmas; 1,655 to Trieste; 22,105 to the Ionian Islands; 9,625 to Smyrna; 6,987 to Metelino; 5,382 to Candia; 1,822 to Calamata; 1,048 to Adramiti; and 3,147 to the various other ports on the Mediterranean.

TRANSMISSION THROUGH PNEUMATIC TUBES.

From "Journal of the Telegraph."

The writer having been employed in designing the extension of a pneumatic dispatch line, in which some heavy gradients were unavoidable, it became necessary to ascertain by calculation the steepest gradient that could be employed, so as to obtain a sufficient carrying capacity in the new section of the line under given conditions of engine power and of length. Almost every text-book and paper on the velocity of gases in pipes, gave a different formula, and the author therefore found it necessary to attempt to construct a convenient expression for the speeds of carriers of given weight and friction, under various conditions of pressure, gradients, and dimensions of tube. The problem of a pneumatic system is simply this: To make a given quantity of air expand from one pressure to another in such a way as to return a fair equivalent of the work expended in compressing it. It is obviously impossible to regain the full equivalent of the work, because the compression is attended with the liberation of heat, which is dissipated and practically lost. Therefore, in designing a pneumatic system, the first thing is to contrive means of compressing the air as economically as possible; and, in the second place, to get back the available mechanical effort stored up in the compressed air, irrespectively of the work employed in compressing and examining it. The writer considers that small pneumatic tubes may be worked more profitably than large ones. The great convenience of and the practical facilities for working small letter-carrying tubes have been amply proved by the extensive systems already laid down in Paris, Berlin, London, and other towns, as adjuncts to the telegraph services. Tubes of somewhat larger diameter would undoubtedly work satisfactorily. Even still larger tubes, of a moderate length, might also be found useful for a variety of special applications. But the author does not believe that a pneumatic line working through a long tunnel could, for passenger traffic, ever compete in point of economy, with locomotive railways. A pneumatic railway is essentially a rope railway. Its rope is elastic, it is true, but it is not light. Every yard run of it, in a tunnel large enough to carry passengers, would weigh more than ¼ cwt. And it is rope, too, which has to be moved against considerable friction, and in being compressed and moved wastes power by its liberation of heat. In a pneumatic tunnel, such as that proposed between England and France, in order to move a goods train of 250 tons through at the rate of 25 miles an hour, it would be necessary to employ simultaneously a pressure of 1½ lbs. per sq. in. at one end, and a vacuum of 1½ lbs. per sq. in. at the other. The mechanical effect obtained of these combined—pressure and vacuum—would be consumed as follows:

In accelerating the air . .	29	millions of foot pounds
In accelerating the train .	12	
By friction of the air . .	5721	
By friction of the train . .	330	

The resistance of the air, therefore, upon the walls of the tunnel would alone amount to 93 per cent. of the total mechanical effect employable for the transmission; while the really useful work would be only about 5½ per cent. of it. And to compress and exhaust the air to supply these items of expenditure of mechanical effect, engines would have to exert over 2,000-horse power at each end during the transmission, even on the supposition that the blowing machinery returned an equivalent of mechanical effect such as has never yet been obtained. This would not be an economical way of burning coals.

The report of the Brighton Railway, presented recently, shows that, reckoning increase of traffic and diminution of working expenses, the result of the half-year has been £52,344 better than that of the corresponding half of 1870, enabling all preference interest to be met and a dividend of 7s. 6d. per cent. to be paid on the ordinary stock, which will absorb £25,649, and leave £2,048. At the same time many improvements have been effected out of current receipts, and as the autumn half-year generally yields about £100,000 more traffic than the first half-year, a hope is expressed that for the whole of 1871 a satisfactory dividend will be realized.

DISINFECTANTS.

From "The Engineer."

Forewarned is forearmed, says the proverb. There seems no reason to doubt that Asiatic cholera is travelling westward on its beaten track, wherefore it behooves us to put our houses in order, so that the enemy may not take us unawares. Since 1832, when the cholera visited us, a desolating mystery, a large stock of experience has been gained; and although medical men, so far from having discovered a specific against it, are not even in accord as to its pathology or treatment, yet a large fund of experience has been gained as to the conditions under which the Asiatic scourge propagates itself from locality to locality. Since 1832 the cardinal point has been determined that cholera, unlike the plague and the small-pox—the latter having much in common with the plague—is not a contagious disease. It cannot be propagated by mere contact; cannot even be disseminated, according to the major weight of authority, by breathing the air of cholera-infected places. The sole condition of its progress seems to be the taking in by the stomach of an organic germ, itself a cholera development. Hence, according to this theory—nay, more than theory, from our point of view an established fact—the restraining of cholera mainly resolves itself into the destruction of this organic germ by one or more things belonging to the repertory of disinfectants. Now it is of first importance to have a clear notion of the nature and agency of disinfectants, bodies which, though designated by one common name, are not equally applicable under all circumstances. Certain disinfectants, though potent as germ destroyers, have a limited application in that way, being themselves poisonous. Some destroy metal work, and therefore cannot well be used for the purification of metallic valvular drains. Some, though efficient, do not admit of use because of their too great expense. Owing to this diverse character it will be well worth while to run through the list of popular disinfectants, specifying the conditions and limits of utility of each. The most in repute of popular disinfectants is chloride of lime, of which the active or disinfective principle is chlorine. The excellence of this material consists in its evolving chlorine so gradually as to be not incompatible with health; for chlorine itself in a pure or concentrated state, or even when considerably diluted, is rapidly destructive of human life when breathed. If the proposition be to destroy the germs of communicable disease in an uninhabited apartment, no agent can compare with chlorine, easily procurable by adding oil of vitriol enough to convert into thin paste a mixture of black manganese with common salt, in equal parts. The mixture should be effected in an earthenware pan enveloped by hot sand, set in the middle of the room to be disinfected, care being taken to depart and close the door before any of the fumes are breathed. Chlorine is a powerful bleaching agent, hence all dyed and printed fabrics, the colors of which it may be desired to preserve, should be previously removed from the chamber operated on, if, indeed, the protection of such things under such circumstances be desired in any case, a precaution not to be sanctioned by considerations of sanitary science. Chloride of lime solution forms an admirable bath for the disinfection of cotton and linen fabrics; but when employed for this purpose soap should never be used.

Next in importance to chlorine and chloride of lime comes the permanganate of potash, the solution of which is popularly known as "Condy's fluid." This disinfectant is very effective under certain known conditions of its efficacy. It is not, like chlorine, volatile; hence it cannot pervade a chamber and search out and attack organic matters, which, therefore, have to be brought into contact with it. Under some conditions this is an advantage, as, for example, in an occupied sick-chamber, where the presence of chlorine, even in an attenuated form, as when slowly developed from chloride of lime, would seriously affect the breathing organs. The evil odors of a sick-room may be entirely destroyed by sprinkling the floor and walls with Condy's fluid, or, perhaps, more effectual still, by hanging rags saturated with this fluid on lines. Perhaps, however, the greatest disinfec-

tant value of the permanganate is referable to the facility with which it destroys organic matter present in water. This fluid itself is deep purple, a tint which immediately disappears when brought in contact with organic matters. Hence it follows that, if on adding a few drops of permanganate solution to a sample of water, the purple tint disappears, this is proof of the existence of organic matter; and if the object be that of purifying water from such by the permanganate, the latter should be gradually added so long as decolorization ensues. The fumes of burning sulphur enjoy a certain disinfectant repute, but the utility of this agent, certainly inferior to chlorine, is limited by the same considerations that limit the utilization of chlorines. Sulphurous acid—and the fumes of burning sulphur are only that—is, however, of inestimable value as a specific disinfectant against such organic germs as result from certain varieties of fermentation. Sulphurous acid checks fermentation absolutely; hence, when brought into contact with otherwise fermentable matter, the conditions for germ formation cannot arise. The repute in which carbolic acid is held as a disinfectant is great, but this agent, though powerful, is not without drawbacks. It is very poisonous when swallowed, and, accordingly, numerous accidents have arisen from accidentally swallowing it. The odor of carbolic acid, though to some not disagreeable, is too strong to be compatible with a wide range of domestic utilization, and its vapor is injurious to the eyes. Amongst the most recently introduced disinfectants is the the compound named chloralum, the active principle of which being chlorine, assimilates it in operation to chloride of lime.

Any notice of disinfectants would be imperfect that should fail to take cognizance of lime wash, one of the most common of disinfecting resources, and one so very much abused that, far from doing good, it is often injurious. About the power of quick-lime to destroy organic germs—indeed all organic matter—there can be no question, and the practice of covering walls and other broad surfaces with thin caustic lime paste is accordant with one of the best disinfective indications. Unfortunately in practice the so-called operation of lime washing is little else than a pretence. The London plasterer, at any rate, is rarely content to make his wash of lime and water alone, he uses a certain portion of tallow and size to give adhesion, and mixes whiting or chalk with the quick-lime to impart additional whiteness. The offensive odor of London lime-wash is too obvious for comment. This depends on the putrefaction of organic matter, the cause, we believe, of more harm than the actual lime can do good. Generally the presence of miasmatous infective matter is accompanied with an evil odor, but practice has demonstrated the possibility of the existence of disease germs without any odorous circumstance. The usual cause of evil smells, as in drains of houses, is the presence of sulphuretted hydrogen gas, an extremely poisonous compound, which, if frequently breathed, lowers the health standard and begets disease. For this reason sulphuretted hydrogen should always be kept under, for reasons independent of organic germs, and perhaps common green vitriol—sulphate of iron—is the very best substance for absorbing this gas. A pound of sulphate to a gallon of water are very good proportions, forming a liquid that admits of use in many instances when others would be inapplicable. For example, chloride of lime cannot be very extensively used in contact with metal surfaces without seriously affecting them. Thrown down the pipes of a closet, for example, it would soon destroy the fittings, whereas green vitriol has the advantage of being utilizable under these circumstances in any quantity without effecting the slightest disintegration.

On more than one occasion we have protested against the abuse of dust-bins. We believe them to be the *foci* of more disease-originating evil than the public would like to contemplate; and, cholera or no cholera, we hold that the free-and-easy way of allowing not only dust, but vegetable and animal organic matter to fester and putrefy there, is not worthy of a civilized people. If servants could only be induced to burn such *disjecta membra* of household refuse as bones, cabbage-stalks, lobster-shells, and the like, merely conveying the ashes of these to the dust-bin, a great sanitary point would be gained; and if, in addition, the heap were daily covered with a thin layer of chloride of lime, or even ordinary caustic lime, the

dust-heap evil—if not wholly done away with—would be reduced to a minimum. Having already touched upon the question of water supply, we shall only now add that filtration is not, in our opinion, effectual in freeing water from any but the grosser mechanical impurities. That the very best of filters can exercise any important chemical effect on water we do not believe, inasmuch as, of whatever material a filter is made, its chemical potency is soon exhausted.

TECHNICAL DICTIONARIES.

From "Engineering."

The "international" tendencies of the present day have not been without influence on the literature of the period, and accordingly we find that within the last few years several works have been put forward which may be classed under the general heading indicated by the title of this article. Pending the adoption of the universal language, which is, we devoutly hope, very far off, certain individuals, more or less qualified (generally less), have set themselves to compile vocabularies, giving the equivalents of technical terms in various languages. We do not propose to enter upon a regular review of any of these works, but intend simply to make a few suggestions for the benefit of authors who think they have a call to enter on the preparation of a Technical Dictionary.

The first and most important requisite of such a book is that it shall present a faithful list of the words in use at the time of publication, and not be overburdened with obsolete and erroneous terms belonging to a past generation. It is for this reason that all dictionaries which seek to recommend themselves as containing so many thousand "additional words" should be regarded with suspicion. It is quite true that obsolete words should appear in what we may call the "first place," for the benefit of those who may be reading old books. For instance, in a good English-German-French dictionary, we should expect to find the word "fire-engine," as denoting the machine now called a "steam-engine," of course with a note to prevent the unwary use of the word by a foreigner writing English. Even so late as 1793 a tract was published under the title of "Introduction to the art of making machines *vulgarly* called steam-engines," thus showing that the word "steam-engine" had by no means gained for itself admission into all circles at the end of the last century. It is, indeed, probable that "steam-engine" and "fire-engine" were used indifferently to denote the same thing for many years after that date. We should *not*, however, expect to find in the French part of our imaginary dictionary the word "fire-engine" given as an equivalent for *machine-à-vapeur*. Moreover, the author should be careful to point out, if he can, the subtle distinctions between such words as "road-steamer," "steam-carriage," "road-locomotive," and "traction-engine." It is here worth noting that "steamer" was once applied indifferently to machines for moving through the water and to those suitable only for locomotion on land. It was probably never used by authors in the latter sense, but the present writer well remembers hearing it applied to locomotives by country people many years ago. We have never yet seen a dictionary which attempted to discriminate between "mechanic," "mechanician," "mechanist," and "machinist." The first of these words has, in London, a local signification, by which it is made to include almost every one whose trade is mechanical; but we fancy that a bricklayer in the North of England would be rather surprised at being called a "mechanic." Again, "machinist" has, since the introduction of the sewing machine, obtained an entirely new meaning. It has also a special signification behind the scenes of a theatre. Similar varying shades of meaning also exist in French and German. For instance, one of the meanings of *mécanicien* is "engine-driver," and we occasionally see in newspaper accounts of French railway accidents that "the mechanician escaped unhurt." We may perhaps one day meet with a literal translation of *chauffeur*, the French designation of the driver's mate, the "stoker" or "fireman." After all, it would not be

so very foreign to the language, as the word still lingers here in that mysterious functionary in the Court of Chancery, whom it was once our privilege to behold in the flesh, we allude to "Mr. Deputy Chaff-wax," whose duty is to heat—*chauffer*—the wax for impressing documents with the Great Seal. However pedantic such an assertion may appear to the "practical man," we shall never have a technical dictionary worthy of the name, unless the compiler brings to his task a certain amount of etymological and philological skill. He must be prepared to notice the peculiar circumstances which influenced the technical terms in new branches of industry. Take an example. It is interesting to note that railways on their first introduction were intended to be a sort of modified "King's highway." All the old railway acts contain clauses providing for the running of private trains. The term "rail*road*" (now discarded here, but still in general use in the United States) shows this to a certain extent, and the analogy may be carried still further by the terms "driver," "guard," "coaches" (as the carriages are still called by the railway employés), and "wagons." Even so late as 1839 we find the author of a book on "Roads and Railroads, Vehicles and Modes of Travelling," saying: "There is a class of stage coaches (if the term be properly applied to them) which have come much into use within a few years; we mean those employed on the various railroads. These vehicles have never to make any of those sudden turns which are required on common roads .... some are shaped like private carriages."

As in general literature so in technical literature, it is entirely beyond the power of any dictionary maker to influence the use or disuse of any particular phrase or word. The dictionary of the French Academy is sufficient proof of this. It may also be said that a new word is never introduced by a dictionary; but when the necessity for it becomes very pressing it springs up mysteriously, and if it happens to suit the public taste, is straightway adopted into the language. "Telegram" is a case in point; but "Bessemerise," founded on the German "Bessemern," which signifies the carrying out of the Bessemer process, has scarcely survived its birth. The word "re-railing" in the sense of replacing a railway carriage on the rail after an accident, is vastly convenient, but has not been generally adopted. Again, we are not yet permitted to say, without a charge of using an Americanism, that two trains "collided." American writers are not troubled with the conservative scruples which hamper us with regard to the invention of new terms, and no German is ever at fault, in consequence of the marvellous facility with which compound words may be formed in that language. But as we have said before, it is not the province of the compiler of a technical dictionary to invent new words, a maxim which some would do well to bear in mind. In many works of this kind the authors appear to have thought that their task was ended when they had ransacked previous authors, good, bad, and indifferent, and simply arranged in order the words so obtained. No note is taken of the gradual change which all language is continually undergoing, and the most ridiculous blunders are propagated. They never seem to think that it is necessary to read modern authors of established reputation for the purpose of recording new words or old words used in a new sense. At the present day, when periodical literature occupies so prominent a position, it is obvious that this search must be made principally in the technical and scientific journals. If any one would only take the trouble to read over a translated article in a leading French or German periodical (he will have no difficulty whatever in finding one), and, with the English original before him, note the rendering of all the technicalities, we can promise him that they will be very different indeed to anything which he will find in the very latest and best technical dictionary. We venture, also, to call the attention of intending lexicographers to another profitable mine which has never been worked as it ought to be. We allude to illustrated trade circulars and price lists, such as Barras & Blackett's "Sheffield Standard List," or Appleby's "Illustrated Handbook of Machinery." By a comparison of these with foreign lists of a similar kind, an immense number of words might be obtained which have never found their way into any technical dictionary. We will venture to say that the advertisement columns of this very number contain at least fifty terms which an unfortunate translator might

seek for in vain in his favorite lexicon; or if he did find them, the majority of the renderings would be sure to belong to the last generation, or perhaps to no generation at all.

In the absence of any reliable technological dictionary the only resource left for a translator, when the context does not clearly indicate the meaning, is to read up the subject in a work written in the language from which he is translating. In this way one may generally succeed, with patience, in extracting the meaning even of the most cloudy German author, and that is saying a good deal. We say generally, because there are some cases in which no English equivalent exists, as, for instance, in metallurgical and other processes which are either quite new or are confined strictly to a particular locality. These are real difficulties out of which all existing dictionaries are unable to help us.

We have refrained from mentioning any dictionaries by name, but should our remarks meet the eye of any industrious compiler, we take the liberty of suggesting that he should discard at least $\frac{3}{4}$ths of the matter which he has accumulated from other authors. A careful revision of the remaining fourth, according to the principles we have laid down, will probably lead to a still further reduction of quantity, and to the improvement of the quality of his work. It should always be borne in mind that 100 words picked up in the workshop or from writers of authority are worth a 1,000 which simply embody the accumulated errors of dozens of ignorant compilers.

EXPLORATION OF THE TIBER.

From "The Builder."

One of the first reflections that occurred to many persons familiar with Italy, on hearing of the fall of the temporal power of the Pope as the master of Rome, was, Now, at length, the Tiber will be explored! It is not for the first time that the work has been attempted. The conviction is strong among Italians that treasures of art, of fabulous amount, have been cast into the turbid river on each successive capture or sack of Rome. Without counting the occasions on which extreme terror was caused in the city by the ravages of the Huns, under Attila, and by the final overthrow of the empire by Odoacer and the Heruli, the capture by Victor Emanuel in 1870—the 2,624th year of the city—was the ninth instance of a successful siege of the capital of Europe. Of these the first (under Brennus in the 365th year of the city), and the three preceding the Italian conquest, were all effected by the same nation, the warlike and restless inhabitants of Gaul. Of neither of these sieges, unless it be of that by the Constable Albert de Bourbon, in A. D 1547, which, indeed, was rather a Spanish than a French feat of arms, can we expect to find any memorial preserved beneath the waters of the Tiber. But on the more fatal occasions of the sack of Rome by Alaric, by Genseric, and by Totila, and possibly on that of the capture by the Greeks under Belisarius, the firm opinion of the Romans is, that despair sought to rob the barbarians of their prey by casting the treasures of the city into the Tiber.

The existence of so long established and firmly held tradition is ample justification for an attempt being made to solve the question. It will not be necessary to incur a very large outlay in the first instance, as a comparatively partial exploration will be enough to prove whether it is worth while to continue the operations on an exhaustive scale. We regard the problem as one of immense interest, although not one of which it is at all easy to anticipate the solution. The present era is distinguished by discoveries in human history, no less than in science. The ancient world is being interrogated, and has only commenced to speak, in an intelligible language, in reply. In Egypt, in Assyria, and in Palestine, a very large amount of positive information as to the history, art, and warlike and social habits of nations now swept from the earth, has been freely forthcoming. In Italy, it must, however, be remembered, the work of exploration is not new. The respect of the Italian peasant for the slightest memorial of *Antichita* can hardly be realized by persons so heedless of their own pre-his-

toric monuments as are the majority of Englishmen. The pride of the Roman in his name and ancestry is enchanced by the high price always commanded by any relics worthy of note. Italy has been thrashed over in the search for coins, gems, statuettes, and terra-cotta lamps and vases. But the riches in the soil in these relics seem almost inexhaustible. The Count of Syracuse, the brother of King Ferdinand of Naples, added much to our knowledge of Roman antiquity, by his systematic exploration of tombs at Cumæ, and elsewhere. Apulia is very rich in remains, and has hitherto lain too remote from the influx of tourists to be by any means exhausted of its treasures. Terra-cotta funereal sculpture, of wonderful vigor and beauty, has been within the last year or two acquired by the South Kensington Museum from this part of Italy. The Government exercises a right over all treasure trove of this nature, and the general object of the law is, both to preserve all structural remains, and to prevent the removal from the country of any portable objects. Thus, in spite of the sloth and corruption of the administration, the *Museo Borbonico* at Naples has become enriched with some of the most exquisite remains of art that have anywhere escaped the ravages of time.

Apart from the architectural remains, which public and private taste al ke respect throughout Italy, the recoverable relics of ancient art mainly consist of coins, gems, mosaic, terra-cotta lamps, vases, and statuettes, bronzes, and marbles. To these six classes of objects the operations at Pompeii have added the discovery of fresco paintings. In addition to this, specimens of food, tools, armor, requisites for the toilette, and personal ornaments of all kinds, have been found in the Campanian cities, and his Royal Highness the Count of Syracuse was in possession of a Roman lady's work-box, made in the first century of the Christian era. Frescoes and mosaics have been chiefly discovered at Pompeii, as the gradual induration of the volcanic ash which buried this city has not proved destructive to ornamentation on walls or floors. On the other hand, bronzes have been, for the most part, much corroded by long contact with the sulphureous tufa. The most perfect and uninjured bronzes have been found at Herculaneum, where the hot lava, pouring round the metal it encountered in its course, has enclosed it in a matrix impenetrable to atmospheric influences, and preserved it in all the freshness of its early state.

With regard to the surmised treasures of the Tiber, two questions occur. First, is it true that so much and so many of the art-treasures of Rome have been thrown into the river; and then, if so, in what state of preservation may they be expected to exist? It is clear that a satisfactory solution can be given to these questions by the operations of the engineer alone.

We may, however, form some idea of what we should seek. Paintings, for instance, which are, from their rarity and other causes, the most interesting relics of antiquity, are here utterly out of the question. The same may be said of mosaics, except in the case of such small objects as fibulæ, or perhaps plaques. Marble and bronze statues are hoped for. In addition to the difficulty that would be experienced, at times when people were principally concerned in saving their own lives, in removing massive and heavy objects of this kind from their stations—and that not for the purpose of actual preservation, but from a questionable kind of art enthusiam, or even spite—the effect of the water of the Tiber, or the yellow mud which it rolls down, on either marble or bronze, during a period of more than 1,000 years, is not to be despised. The waters of the Italian rivers are often charged with salts of volcanic origin, none more so than some that are sparkling to the eye and soft to the touch and taste. A period of 50 years has been enough to eat away a great portion of the iron-work of vessels sunk in the Seine, leaving the remainder in the state of silver-like threads of great purity and beauty, but retaining little of the form of the object of which they composed a part. In the Seine, however, there is no trace of the sulphureous elements frequent in the Italian waters. Thus it will be only on the actual discovery of some uninjured work of ancient date, in marble or in bronze, that we shall be justified in looking with any confidence for more. The very first few days of a serious and well-ordered exploration will possess the utmost interest for all lovers of art.

For terra-cotta again, it is pretty clear that we shall look almost in vain. Quite imperishable as this material would be,

from chemical causes alone, its fragile texture, and the low intrinsic value of the articles of which it supplies the material, are such as to lead us to expect nothing but fragments of earthenware from the bed of the Tiber. Of course more is possible, but it is not, in our opinion, probable.

It remains, therefore, that the treasures which may most reasonably be expected from the careful exploration of the Tiber will be coins and gems. Nor can it be considered as improbable that ornaments of the person or of the habitation, composed of the more precious metals, will repay the toil. On gold, silver, and the hard stones of the agate and corundum families Father Tiber may try his teeth for a long time in vain. Objects of small size would be very likely in the first instance to be dropped or thrown into the river, and in the second place, to have sunk alone into its bed, and buried themselves from further disturbance.

For objects of this nature, of high intrinsic and artistic value, and requiring care like that of the diamond-washer to detect, it is clear that only a well-ordered and systematic search will be suitable. The Italians have great experience in research. The *scavi* at Pompeii have assumed the form of a regular industry, under the direction of the State. Nor have the engineers of Italy been slow to learn all that has been effected in the profession in England and in France; and in the execution of the Mount Cenis Tunnel they have far outstripped their French partners. But they are less experienced in dealing with the water. Their tideless seas, and, with few exceptions, riverless coasts, have afforded them no opportunities for such operations as are familiar to ourselves. Their one great river, long the tyrant and devastator of its fertile basin, has been tamed, so far as is yet effected, by Englishmen; as to whose treatment in the matter the less that is said the better. The experience gained in the canalization of the Po will be of little avail as to the exploration of the Tiber. The conditions in the latter case, are unique. It will be essential, in order to obtain any adequate support from this country, for something of our own large professional experience in tidal and submarine works, in river walling, and in sinking the foundations of river bridges, to be brought to bear upon the works attempted in the Tiber. On former occasions, when great interest was excited in this country on the subject, when money was forthcoming for the search, and when only the steady and stolid opposition of the Papal Government prevented the solution of this secular problem from being attained, it was taken as a matter of course that the works would be directed by English skill and energy. Italy has made enormous strides since that time in her mechanical excellence; but no men will be justified, in a matter of such European interest, in failing to avail themselves of the experience gained in the raising of the Royal George, in the bridging of the Tamar, the Medway, and the Thames, and in the recovery of Roman relics from the mud of the river Fleet.

In fact, it must not be doubted that for the exploration of the bed of the Tiber to be attempted with any satisfactory result, it must be confronted as a serious operation of the civil engineer. No peddling, no amateur work, no trusting to the chapter of accidents, can lead to success. The work must be undertaken under competent authority. Either the Italian Government must itself take it in hand, as in the case of the excavations of Pompeii, or it must give to the company or association undertaking the enterprise a definite and exclusive right, for a fixed period, to deal with an agreed portion of the Tiber. The proprietorship of objects recovered must be distinctly ceded to the company, any Government reservations or claims being renounced, or reduced to well-defined limits. Preliminaries being thus properly arranged, the next step will be to make such a thorough investigation of a measured area of the bed of the river, as may afford some basis for future calculations. This may be done by means which are perfectly familiar to English engineers, at small and definite cost, and with an exhaustive result. In case of failure, a second, and even a third exploration of spots selected in different parts of the channel would be proper. If the result confirm the sanguine expectations of the explorers, there will be no difficulty in raising the capital necessary for a proper inauguration of the enterprise upon a sound practical basis. If then such searches as we suggest, should prove unavailing, as we fear they might, we should recommend the abandonment of the design.

Should the preliminary investigations have the result of proving that Art relics of value are actually embedded in the mud of the Tiber, and that the chemical effect of the water has not proved so corrosive as to reduce bronze and marble to shapeless deformity, we shall have before us a very notable and important enterprise. If a long-lost chapter, or series of chapters, in the history of Rome may be thus regained, neither cost, nor toil, nor patience, must be spared in adding so precious an illustration to human knowledge. Above all, it will then become necessary that impatience and slovenly work should be avoided, and that Tiber, if put to the question, shall be made to yield up the entire truth. It is obvious that this can only be done by an operation of the most complete kind. The sanitary state of Rome will be materially affected by the proper regulation of the Tiber; and questions of sewerage, drainage, and protection against the ravages of flood, will all demand proper forethought and skilled settlement. Any attempt to save expense in the first instance, or to dribble away time and money in successive potterings with sections of the Tiber, will involve failure. The objects which we conceive to be most likely to repay the toil of the explorers, are precisely those which nothing but a thorough and leisurely exploration can reveal. Working against time in the bed of a river subject to floods, and with the scene of operations only partially bared, or imperfect'y protected, would yield but scanty result in the shape of gems, coins, or small articles of personal ornament. The extraction, uninjured, of large objects of sculpture or of architectural character, if met with, would be equally out of the question, unless the engineer of the undertaking has his work clear and open before him. A diversion, or series of diversions, of the stream will be a necessary feature of the case. It is unnecessary for us to come uncalled for into council, or to point out, unasked, the proper methods, either of making at once the cheapest and the most thorough preliminary search, or of uniting the various objects of sanitary improvement, and of provision for the discharge of flood-water. It is, indeed, possible that the Romans may choose to deal with their historic river after their own fashion. In such a case we shall have nothing to do but look on with interest, both at the engineering and at the archæological results. But in cases of this kind it is the usual custom of our continental friends to come to this country for money. Lovers of art in England have already been appealed to, to support the great enterprise of the exploration of the Tiber. It is to them that we speak, with all the earnestness which acquaintance with Italian life, and longer acquaintance with subaqueous and fluviatile operations, render natural, and, we hope, pardonable. It is quite possible for a considerable sum of money to be spent, not only uselessly but mischievously. For if the attempt be now made in any but the proper manner, the result will be the final abandonment of all the buried stores of Tiber, be they more or less. Let no Englishman, then, further the scheme in any way, unless he be assured as to the conditions under which it is to be carried out.

In a word, if in searching the bed of the Tiber we are not told once more, *Italia farà da se*, we have nothing to do, in this country, but look on with interest. If Italy comes to London for aid, that aid ought to be afforded only on the clear and distinct conditions to which we have referred. A definite Government concession, in which at least one English name is inserted, must be a *sine qua non*. Then, a plan of operations must be laid down by an English engineer, and faithfully carried out under his direction. In this case we shall be able, first to know what we are about, and then, if we decide to go on, to do so to certain good results. Rome will, in such case, be certain to benefit by the permanent effect of the river works carried out; and it may possibly be the case that the museums of Europe will receive such additions to their stores as shall prove worthy companions to the Elgin and Phigaleian marbles in the British Museum, to the busts and statues of the Vatican, and to the exquisite *camei* and unrivalled bronzes of the Museo Borbonico at Naples.

The North Staffordshire Railway Company are raising funds for their Tunstall and Potteries loop lines, which they must complete by July, 1872, under a penalty of £50 a day thereafter.

LAKE SUPERIOR AND THE COPPER MINES.

From the "Boston Journal of Chemistry."

Lake Superior has always been to us one of the wonders of the world. Although it was discovered by the Jesuits before Lake Erie or Lake Michigan, a great portion of it still remains almost unknown and unexplored.

The white man has merely encroached on its southern and western shores, while the great country to the north of it still remains almost the *terra incognita* that it was when the Jesuits founded their lonely mission at the entrance to the "great sea water," the Gitchee Gumee of the Indians. There, at the beautiful Sault de Sainte Marie, the Mission bell still rings its matins and vespers, and the good Fathers may still be seen in the streets with their long gowns and broad hats. The Indians still fish in the rapids for their favorite white fish, holding, with the aid of a single paddle, their birch-bark canoes as motionless as a vessel at anchor, while the current seethes and boils around them. But the restless American has been at work here, and a broad, deep canal connects the water of the lake with the quiet river below the rapids. This was constructed by a company who received a land grant from the United States. The tonnage passing through this canal is every year becoming heavier, for it conveys the products of the vast iron mines near Marquette, and the copper mines of Keweenaw Point, and soon the vessels bringing the products of the new country opened by the Northern Pacific road will begin to pass down.

From the times of the earliest trappers, it has been known that there were great deposits of copper somewhere around Lake Superior, but the Indians, who were always willing enough to sell the copper, refused to tell of its whereabouts. And it is only within comparatively recent times that the mines have been opened and worked. A trip to these mines is an extremely pleasant excursion, and one that may combine a great deal of instruction with pleasure. Boats sail regularly several times a week from Buffalo, stopping at Detroit, and going up the lakes as far as Duluth. The best point, however, for seeing the copper business, is Houghton, on Portage Lake, as this is in the centre of the mining region.

Portage Lake is a curious sheet of water. It cuts Keweenaw Point almost in two, and formed a short cut for the Indians who travelled in their birch-bark canoes. They never ventured far from shore, and this inlet saved them many weary miles of paddling around the point. But, to make up for this, they had a "carry" of half a mile at the head of the lake, across to the west shore of the point; and from this the lake takes its name. The white man has improved on this again, by cutting a ship canal through this half mile of sand, and the largest steamers now pass where once the Indian wearily carried his canoe.

The mines lie on both sides of the lake near Houghton, and extend along the point, and westward toward Duluth. Some copper has also been found on the north shore of Lake Superior, but the principal deposits seem to be those of Keweenaw Point. The road from Houghton to Eagle River passes by some of the most interesting of these mines, and, among them, the Calumet Cliff and Phœnix. This latter mine is somewhat celebrated, as being in the same predicament as the man who bought the elephant. A mass of copper was struck some years ago, which has been estimated to weigh more than 350 tons. It is pure metallic copper, in one single piece; and the question was, What to do with it? They could not raise it in a single lump, and it was so compact that they could not blast it. They at last resorted to drilling off piece after piece; but this cost almost as much as the copper is worth. Nearly the whole of the copper mined here is found in the state of metal, and only needs to be smelted to free it from the rock, and fit it for use.

The Cliff mine is one of the most interesting, as it penetrates deeper into the earth than any other mine in America. We selected this mine for examination, partly from this reason, and partly because it was one of the best supplied with labor-saving appliances in the region.

It is an old saying, that when you are

in Rome you must do as the Romans do; and when you go into mines you must do as the miners do. So we took off our clothes, and arrayed ourselves in the coarse canvas apparel of the miners. It must be confessed it did not improve the appearance of the party. Each of us was provided with a coarse canvas hat, furnished with a pad inside to protect the head from falling fragments of rock, and, on the outside, with a lump of clay in which to carry our candle. Thus equipped, we commenced our descent. A miner led the way, followed by the party, while another miner closed the procession, in order that there might be no stragglers. The descent for the first 750 ft. was comparatively easy, as we went down on the "man engine," which is a curious affair, made expressly for conveying the men to and from their work. Two beams of wood, a foot square, and 750 ft. long, are suspended alongside of each other at the distance of about a foot. These beams are so connected with a walking beam, that they have a perpendicular motion of 10 ft. At distances of 10 ft. apart are fastened foot-boards, on which a man can stand, while 4 or 5 ft. above the foot-board is an iron handle, which he can grasp. When a man wishes to descend, he steps upon the foot-board which is at the top of the shaft; he is then lowered 10 ft. by the motion of the beam, and finds himself opposite a foot-board on the other beam, which is then at its highest point; he steps across to that board, which then commences its descent, while the one he has just left is ascending. When the second beam reaches its lowest point, the first is again at its highest, and he steps back to another foot-board on the first, which is then lowered in its turn. This process is kept up until he has gone down as far as he wishes, when he steps from the beam into a gallery.

Our party all safely accomplished the descent, notwithstanding the loss of a candle or two, which went flaming down into the depths below us. It is a dangerous piece of machinery, however, and a year seldom passes without some fatal accident. The miner makes a mis-step in the dark, and is picked up a shapeless mass from the bottom of the shaft. After leaving the "man engine," we walked some distance along a gallery, and then began the real work of the descent; for it was yet nearly 500 ft., or 80 fathoms, as the captain of the mine expressed it, down to where the men were at work. So we still kept on, down over ladders fastened to the rock, the wooden rounds being sometimes almost worn through, at other times gone altogether; while here and there one would be replaced by an old drill. But at last we found ourselves among the miners. Now and then, we would be startled by the dull thud of an explosion, that told us they were blasting in other parts of the mine. We were introduced to the captain of the mine, who kindly offered to explain to us the whole process of mining. The vein of copper-bearing rock varies here in thickness from an inch to about 2 ft. A shaft is first sunk twelve fathoms deep, which may, or may not, be on the vein; in the latter case, a horizontal drift is extended until it strikes the vein. Galleries are then driven in both directions along the vein, which are called the *levels*. The mine is now ready for work, or *sloping*, as it is called. This is commenced by working away the top of the level, until it is about 10 ft. high, the men standing on the fallen rock to do the work. They first break away the rock, and having thus exposed a large surface of the vein, this is taken out. After they have thus got to some distance above the floor of the level, heavy timbers are put across from wall to wall, and on these are laid others, lengthwise of the level. They then begin work again, throwing the rock on these timbers, and the copper upon the top of the rock. Openings are left at intervals of every 200 ft. in the timber roofs of the galleries, which are framed around with heavy timbers, in the same way that log-houses are built; these are called *mills*, and serve to conduct the ore to the level below, from whence it is removed in cars to the main shaft. This process of working obviates the necessity of raising much rock to the surface.

After spending an hour or two watching the miners at their work, we prepared to ascend to daylight once more, after securing specimens of copper as souvenirs of our visit. The copper looked just as bright and fresh as if it had been burnished. The pieces varied in size from grains of sand to masses that would weigh 50 or 60 lbs.

The ascent was far more tiresome than the descent, and we were glad when we

stood once more at the foot of the "man engine." This brought us quickly to the surface. After changing our clothes, we proceeded to look after the copper that had already been brought up. We found that it was assorted into two sizes, at this mine, called respectively *barrel* and *stamp* work. The barrel work included pieces that were so large that they could be readily sorted out by hand, and packed at once in barrels. The stamp work, or *metal*, was composed of rock and copper, so thoroughly intermingled that it was impossible to pick out the copper by hand.

This was taken at once to the *stamps*. These vary in form, from the simple Cornish stamp—which is a bar of wood or iron, furnished at its lower end with a heavy shoe of cast iron, and having, near its upper extremity, a lug which engages in a tooth placed on a revolving shaft, like that of a trip hammer—to the highly complicated steam hammer. But they all answer the same object—that is, to reduce the ore and rock to a fine state of division. As fast as it becomes sufficiently fine to pass through the screen in front of the stamps, it is carried off by the stream of water that is constantly flowing through them. The further separation of the ore and copper is now effected, on the principle that if you agitate two substances together in water, the one having the greater specific gravity will sink to the bottom, while the lighter will be carried away by the stream. Many curious and interesting devices have been invented for this separation, but they all depend on this same principle. By continuing this operation long enough, the ore is at last obtained almost entirely free from rock. It is then packed into barrels, and is ready to forward to the smelting works; for although it is now nearly pure copper, it is in too finely divided a state to be of any practical use.

A small amount of native silver is also obtained in these mines, but the most of it finds its way into the pockets of the workmen. Lake Superior copper is the purest that is mined in the world, the only impurity being a trace of silver.

At the smelting works, which we visited at Detroit, on our way up the Lakes, all the complicated processes of the Swansea (England) works are dispensed with.

The copper, when it comes to the works, is already in the metallic state, and only requires to be melted. We found there, in addition to the barrel copper and stamp work, another description of ore known as *mass*. This consisted of huge masses of copper, some of them weighing 8 or 10 tons. The furnaces used are reverberatory, and resemble those in iron works, except that the top is movable, in order to introduce the mass copper. After the copper is melted, it is stirred with green wood poles, to reduce the oxide formed during the melting, which would, if allowed to remain, make the copper brittle. It is then dipped out in iron ladles, and run into ingot moulds. Notwithstanding the great excellence of the Lake Superior copper, it can only compete with that of foreign manufacture, by reason of the excessive duties levied on all imported into the country. The ore can be taken from Chili to Swansea, reduced, and brought to this country, at a lower rate than that for which the mine owners on Lake Superior can afford to work.

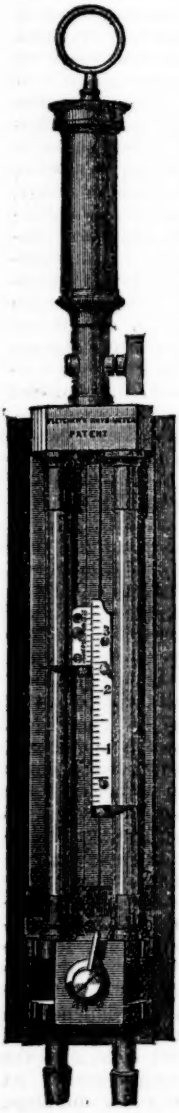
An additional amount of traffic was expected to accrue on the Dunaburg and Witepsk Railway line during the present year by the opening of adjoining lines, of which that from Witepsk *via* Smolensk to Moscow would be the most important, and was to be opened for traffic within a few months. In view of the increase of traffic which had already occurred, and which was further anticipated, the Directors have at the formal requisition of the Imperial Government made a considerable addition to the existing rolling stock, nearly the whole of which has been delivered on the line. During the past year the railway has been inspected by the Government inspector, whose report is most favorable as regards the state of the works and the mode in which the traffic generally is carried out.

Three new stations on the City and Suburban line of the Midland Railway were opened lately for public traffic:—The first from London is at Child's-hill and Cricklewood, to which 15 trains will run to and from all stations on the Metropolitan Railway; the next at the Welsh Harp, Hendon, to accommodate the pleasure and fishing parties visiting that spot; and the next at Flitwick, 2 stations on the London side of Bedford.

THE RHYSIMETER.*

By A. E. FLETCHER, F. C. S.

From "Engineering."



The principle on which this instrument is constructed resembles that of the anemometer, recently brought into notice by Mr. Fletcher, by which he is able to measure the speed of hot air, flame, and smoke, contaminated with dust or corrosive vapors, as met with in furnace flues and factory chimneys. Both in the anemometer and in the rhysimeter, the impact force of the current, and also its tendency to induce a current parallel with itself, are measured, and made to become indicators of the force and velocity of the stream.

The apparatus is very simple. A compound tube with 2 orifices at the bottom, one of which faces the source of the current, while the other faces the opposite direction, is held in the stream, and communicates by tubes with the indicator where the pressure is measured by colums of ether, water, or mercury, according to the circumstances of the case. When used to measure the velocity of a brook or open stream of water, the speed at any depth or at any portion of its surface can be separately estimated.

For taking the speed of water in pipes it is only necessary that there should be suitable cocks screwed into the pipes at the required places; through these the "speed-tube" of the rhysimeter passes without allowing any escape of water, whatever may be the pressure.

A still more important application of the instrument is to measuring the speed of ships. Here the speed-tube pierces the bottom or side of the ship, and projects a few inches into the water outside. The indicator may be in the captain's cabin. It resembles in size and appearance a barometer. In it a column of mercury indicates continually the speed of the ship. The full effect of the velocity is imparted to the mercury, without loss by friction or otherwise, so that the indication must always be absolutely correct. The instrument may be made self-registering, showing by a dial the total number of knots the ship has run since she left port, and marking on a sheet of paper the speed attained at every portion of the time. This permanent register may, in many cases, be of the greatest value.

The rhysimeter is already fixed on board some of the large mail steamers running from Liverpool to the United States and Canada, and has proved itself to be of the greatest value. It entirely supersedes the crude process of throwing the log, since it indicates, by simple inspection the exact speed of the ship in any weather.

The paper was illustrated by diagrams, and by tables showing the velocities in knots per hour, or in feet per second, for the various heights of the columns of water or mercury. Several handsome specimens of different forms of the rhysimeter were exhibited.

* An instrument for indicating the velocity of flowing liquids, and for measuring the speed of ships through water. Abstract of a paper read before the British Association.

In 1720 porcelain factories were erected in Vienna, in 1751 in Berlin, in 1755 near Munich, in 1765 in Sèvres, France, where the most beautiful porcelain ware of the whole has since been produced; in 1795 in St. Petersburg, Russia, in 1720 in Copenhagen, at a still later date in England, and in 1830 near New York city.

THE DOME IN POINTED ARCHITECTURE.

From "The Building News."

Amongst the small and unfashionable minority who look on Gothic principles, not as articles of faith transcending reason and demanding absolute and unquestioning obedience, but simply as rules laid down by the human intellect of one age, and capable of being revised or improved by that of another, it has long been a question why they should not be applied to domical construction. It may perhaps be answered that the use of the dome would imply the abandonment of all the mediæval features which had their origin in the cross vault, such as the buttress, the pointed arch, and perhaps even the gable. On examination, however, this position will, we think, prove more plausible than true. Even as regards the buttress, we doubt it. In a polygonal dome, with ribs at the angles, the main thrusts may certainly be connected into points and resisted by buttresses; while even in a hemispherical one, the same end might be gained by a skilful use of leaning arches. As to the pointed arch, however, the case is still plainer. It is no question of theory here; the pointed arch and the circular dome have been, as a matter of fact, combined in more styles than one. Just by way of calling attention to the subject, we will notice a few instances of their combination.

The earliest in point of time are probably those supplied by the Saracenic architecture of Egypt, and the best known examples are the mosques and tombs at Cairo. Amongst these may be found domes either circular or pointed in section, used, in each case, sometimes with round and sometimes with pointed arches. At the Barkauk Mosque, Cairo, both domes and arches are of the latter class, the points, however, being obtuse, and only just perceptible. The great dome, as usual, is considerably stilted, and its tambour, or upright face, is pierced by a range of lights. As usual, too, it is completely visible on the exterior, for the Mahometan builders, unlike the Romanesque ones, did not enclose their domes in a tower to serve as abutment. They so constructed them as to stand alone, thinning and lightening them towards the top, and weighting them near the base, so that even after their supporting walls are rent and decayed, some of them still stand as perfect as if they had been hollowed from one vast block of stone. Their base is usually square, and the transition from the rectangular to the circular plan is managed in several different ways. Externally, the square is often brought into an octagon, by sloping broaches, like magnified chamfer stops; but these, instead of being mere weatherings, as in a Gothic spire, are more frequently formed by a series of bold mouldings. On this type there are several variations at the tombs of the Caliphs, a mile or two from the city of Cairo. A different type, also common, is found at the Mosque of Hassan, and in this the square is carried up without alteration, and finished with an elaborate cornice; but, whichever plan is adopted, the dome rises clear of the summit. Very often it has no abutment whatever beyond the material contained in its own thickness. This, at the Barkauk Mosque, is about 2 ft. 6 in. in the tambour, or upright cylindrical portion below the springing of the curve. The wall of the square area beneath, at the same place, is not less than 6 ft. thick, and if it received the direct thrust of the dome, would be amply strong enough to counteract it. But the point at which, according to all ordinary calculations, this thrust tends to operate is many feet higher up. It is considerably above even the line or springing at which the curve commences; and yet even between the springing and the thick wall there is almost always, in these Egyptian buildings, a long stilt or upright surface, perforated by a range of windows. How these domes contrive to stand, and especially how some of them outlast the partial ruin of their supporting walls, is therefore in part a mystery. It certainly cannot be explained on ordinary theories of equilibration, but probably depends on the jointing of the stone, the skilfulness of the workmanship, and especially the tenacity of the connecting cement. At any rate, the durability of these buildings, some of them little less than a thousand years old, in a country where earthquakes are neither so rare nor so slight as they

are in our own, says much for the strength of domical construction. It might have puzzled the ablest of Gothic masons to raise a wide cross vault, with no abutments, on four or five yards of thin upright wall, and had the feat been accomplished, we question if it would have remained, even under the most favorable conditions, for modern eyes to see. The great dome at the Mosque of Hassan is about 70 ft. in diameter internally, and though in this instance the tambour is somewhat thickened by a complicated system of offsets, the addition is certainly not enough to render it stable by the mere effect of gravity. Of course, none of these domes had a cupola on the top, to weight them in the one place where of all places weight most needs to be avoided. They have not (or at least most of them have not) even a horizontal crown. They are slightly pointed in section, and turn up, on the outside, into a delicate ogee, ending in a bronze finial. The largest of the mosque domes, however, are not those which are most closely connected with our subject. Springing from a square area enclosed by walls, they do not illustrate, so well as some of the smaller ones, the use of domes in conjunction with arches. Such arches as are connected with them are naturally those of a secondary class, and of a span no greater than that of an ordinary door or window. But there are other domes to be found in these Mahometan works which have a vital and structural connection with arches, being supported by them entirely, and being connected with them, as in Byzantine works, by domical pendentives. The difference is, that in the Greek churches the arches are semicircular; in the Egyptian mosques they are as frequently pointed. This is the case, for instance, in the sanctuary of the Barkauk Mosque, where each dome rests on four piers, and is carried by four pointed pier arches. There is no string-course, and no difference of curvature, above their summits; the same dome which spans the area is continued down to the springing to form pendentives. The effect, though apparently artless, is very pleasing; the work is substantially done in the most unpretending way, and this simple style of construction has a grace and repose which are rarely found amidst the complicated groin ribs of the later Gothic.

Almost the same combination which prevailed in the edifices of mediæval Cairo still finds favor in those of modern Persia. There, too, the pointed arch and the dome are used together, though the curve either of one or both is generally compound, instead of being simple. The four-centred arch, in fact, has been almost universal there, until the upper part of the curve, growing flatter by degrees, has become absolutely straight, and the arch has become an angular one, with merely the haunches rounded. We do not mention this peculiarity to recommend it, for though compound arches are often convenient, they are rarely beautiful. The influence of custom is needed before we can even appreciate the work in which they exist, and allow for the real excellences which may exist even under this strange and unprepossessing disguise. The Persian architecture of the last three or four centuries shows in abundance the faults of a decaying style. It is "late" and "debased" in the same sense in which our own Tudor architecture is so; but, like it, it contains some magnificent and suggestive ideas for those who can distinguish an idea from the mode in which it may happen to be expressed. Nothing which it contains, however, seems more suggestive than its combinations of domes and arches. Of the former, some, though not many, have the plain pointed profile, as in certain parts of the Great Mosque of Mesjid-i-chah, at Ispahan. Here, for instance, is an apartment square on plan which is brought into an octagon above by four-centred arches spanning the angles, and upon these is placed a dome differing little in section from the principal ones at Cairo. The Pavilion of the Eight Gates of Paradise, Ispahan, in spite of its faults of style, is a work of striking beauty. It is octagonal, with the oblique faces of the octagon considerably narrower than the rest. Each of the longer ones is open to give entrance, and is spanned by a great four-centred arch. A passage of the same width leads from each archway to the exterior, forming, in fact, a corridor roofed by transverse ribs similar to the arch. But though there are four great archways leading into the apartment, they are not all alike. Two opposite to each other, are lofty enough to cut into the dome which spans the interior; the other two are only half as high,

and have a gallery above them. Over this gallery, however, the arches are repeated, springing from and rising to the same levels as the two loftier ones, while the diagonal faces are widened out by other arches, so that the lowest point of the dome may be considered as resting on a symmetrical octagon. The dome itself is a wonderful specimen of corbelling over and honeycombing; there is scarcely an inch of flat surface about it, and no description unaccompanied by views can convey any notion of its appearance. It is lighted from above, in a striking and effective way, by a circular lantern opening into a large ring near the summit. The bazaar of the ta lors, Ispahan, is very similar to this in arrangement, but much simpler in detail. It illustrates what is one of the peculiarities of Persian dome construction—namely, that the pendentives do not always stop at the apex of the supporting arches. On the contrary, they often continue to rise, and to converge inwardly for some distance beyond, so that the dome which is planted on them, instead of corresponding on plan to a circle touching the inner faces of the walls, is much smaller, and sometimes not more than two-thirds or even half the size. In the bazaar at Kacham, Persia, there are some remarkable applications of the pointed dome. It seems, in fact, to have been used in all sorts of situations, treated with the greatest freedom, made to bend and adapt itself to almost every shape and use for which a roof covering could be required. Thus we not only see domes on octagons and irregularly canted squares, but, in the great hall of the bazaar last referred to, even on an oblong more than twice as long as it is wide. Practically this is covered by three domes side by side, but there are no great transverse arches to separate and support them. There are mere mitre lines or arrises where one dome intersects with another, and even these are so faintly marked that they would scarcely show in an outline section. From all these and many other instances one fact is clear, that the Persian builders found the combination of domes and pointed arches a thoroughly practical and useful one, capable of being applied to the most various and widely-differing circumstances. They thoroughly mastered it in all its variations, and though, unfortunately, they worked in a degenerate and decaying style, they have done quite enough to show of what admirable results the system is capable.

Should any one think it a fault in the combination under notice that it was originated by Mahometans and misbelievers, we may remind them of a more orthodox application amongst the churches of Southern France. S. Front, Perigueux, and the long list of ancient buildings which are closely related to it, show the same type in a form perhaps better fitted for our instruction. Why, before the origin of the Gothic styles, these buildings came to exhibit pointed arches, is a question perhaps hardly yet decided. Mr. Fergusson has made the important suggestion, that in this early instance, as well as in the later, and far more familiar Gothic one, the form was introduced for structural reasons. It has at any rate structural advantages for the purpose; and in connection with the dome, too, it has great artistic merits. Roughly and barely as it is sketched out in these early examples, a more beautiful combination of lines can scarcely be found. If we want a new and untouched basis for modern art, here it is. Even with no ornament at all it is surpassingly graceful. The mere form and shadow of a dome on pointed arches are enough to constitute an admirable design by themselves; they do not ask for decoration to make them passable. Yet, on the contrary, they do not shrink from it. There is no better field for wall painting and mosaic than these grand unbroken surfaces. They will not attract the third-rate ornamentist, the man who relies on tracery and trash to make his designs go down. But they will commend themselves to the truly practical one, who aims at fulfilling modern requirements, and fulfilling them in a permanent and lasting style. If we want to throw our churches open and fit them for modern uses, the dome has everything to recommend it, for by the use of domes it is always possible to have wide spans and few obstructions. If we want to make them dignified and ornamental, the dome will be of equal service; no permanent covering is so cheap, so easily constructed, or so strong. If we want, in short, to develop an architecture of our own instead of repeating the architecture of others, to explore a new mine of treasure instead of groping

in the half-exhausted workings of the Middle Ages, we shall do well to turn our attention to the dome in combination with the pointed arch.

THE CAUSE OF LOW BAROMETER IN THE POLAR REGIONS AND IN THE CENTRAL PART OF CYCLONES.

By WILLIAM FERREL, Cambridge, Mass.

From "Nature."

In none of the treatises on Meteorology or Physical Geography is there to be found any satisfactory explanation of the observed low barometer in the polar regions, or in the centre of a cyclone. Observations show that in the Antarctic region there is a permanent depression of more than 1 in. below the average height nearer the equator, and in the Arctic region a depression of about half that amount; and also that for several days frequently the barometric pressure of the central part of a cyclone is 1 or 2 in. less than that of the exterior part. Mr. Buchan, in his excellent treatise on Meteorology, attributes the low barometer in the polar regions to the effect of the vapor in the atmosphere. If the amount of vapor in the polar regions was greater than in the equatorial, this effect, so far as it would go, would be in the right direction; but just the reverse is the case; for it is well known that the amount of vapor in the warm equatorial region is much in excess of that in the cold polar regions. Attempts have also been made, without success, to account for the depression in cyclones by the effect of centrifugal force.

By whatever cause so great a difference in the barometric pressure in the different regions might be produced, it may be shown from the principles of dynamics that the equilibrium would be restored in a very short time, if there was not some constant force tending to drive the atmosphere from the polar regions towards the equator, or from the centre of the cyclone to the exterior, and to keep it in that position. Such a force may be found in the influence of the earth's rotation. In a paper by the writer in the "Mathematical Monthly" in 1860, published in Cambridge, U. S., a full abstract of which was also published in the January No. of "Silliman's Journal" for 1861, the following very important principle was demonstrated:—In whatever direction a body moves on the surface of the earth, there is a force arising from the influence of the earth's rotation, which tends to deflect the body to the right in the northern hemisphere, and to the left in the southern hemisphere. This force, which is the key to the explanation of many phenomena in connection with the winds and currents of the ocean, does not seem to be understood by meteorologists and writers on physical geography. We see it frequently stated that the drift of rivers and currents of the ocean running north or south always tends to the right in our hemisphere, and that a railroad car running north or south presses to the right; and this is the case. But the same is true, and to exactly the same amount, of a current or of a railroad car running east or west, or in any other direction.

The amount of this deflecting force, when the velocity of the body is small in comparison with that of the earth's rotation, is expressed by $2.\frac{1}{289}\cdot\frac{v}{n}\cos.\,\theta\,g$; in which v is the lineal velocity of the body relatively to the earth's surface, n that of the earth's rotation at the equator, θ the angle of polar distance, and g the force of gravity. If the velocity is expressed in miles per hour, the expression in round numbers becomes $\frac{v\cos\theta}{150{,}000}g$; that is, for each mile of velocity per hour, the force is $\frac{1}{150{,}000}$ of gravity, multiplied into the cosine of the polar distance. Hence a railroad car on the parallel of 45 deg. north, running in any direction at the rate of 40 miles per hour, presses to the right with a force equal to about $\frac{1}{5{,}000}$ part of its weight.

The effect of this deflecting force upon what Mr. Stephenson calls the barometric gradient is easily estimated. Since the strata of equal pressure of the atmosphere,

so far as this force is concerned, must be perpendicular to the resultant of this force and gravity, the sine of inclination of any such stratum to the earth's surface must be $\frac{v \cos \theta}{150.000}$, and the change in barometric pressure for any given distance is equal to the weight of a column of atmosphere of a height equal to the change of level of the stratum of equal pressure and of a density equal to that at the earth's surface. The barometric gradient, then, as expressed by Mr. Stephenson, for any distance d expressed in miles is $\frac{v \cos \theta d}{5 \times 150.000} \times 30$ in.; putting 5 miles for the height of a homogeneous atmosphere, and 30 in. for the pressure at the earth's surface. Round numbers are used throughout, since it is only the order of the effects we wish to determine, and not their exact amount.

According to all observations, there is a steady and very strong wind blowing all around the earth in the middle and higher latitudes of the southern hemisphere, with a velocity of at least 25 or 30 miles per hour at the surface of the ocean, and this is perhaps much greater in the upper strata of the atmosphere. If at the parallel of 50 deg. we suppose the velocity of the wind v to be 30 miles per hour, the preceding expression of the barometric gradient for a distance d of 5 deg. or 350 miles, using the cosine of 40 deg., is 0.33 in. of mercury. By reference to § 113 of Mr. Buchan's Meteorology, it will be seen that the barometric gradient for that parallel is only 0.28 in. for 5 deg. of latitude, and that this is about the maximum gradient in the southern hemisphere. Hence a velocity less than 30 miles per hour at the surface of the sea, especially if we suppose that it increases in the higher regions, is sufficient to account for this maximum barometric gradient; and, according to observations, 20 or 30 miles per hour for the wind in that region is no unreasonable assumption. The eastward velocity of the wind in the different latitudes being known, and, consequently, the corresponding barometric gradients, the difference of barometric pressure between any parallel near the pole, and one towards the equator, is readily obtained by integration. As the wind near the equator is toward the west the deflecting force there is *toward* instead of *from* the pole, and hence the greatest barometric pressure is about the parallel of 30 deg., and there is a slight depression at the equator. The deflecting force and the consequent depression are small, then, on account of the small value of θ near the equator.

Since there is more land and mountain ranges in the northern than in the southern hemisphere to obstruct the eastward motion of the atmosphere, its velocity is not so great, and consequently the polar depression is much less there than in the southern hemisphere. According to Mr. Buchan the barometric depression in the Arctic regions is much greater in the northern part of both the Atlantic and Pacific oceans, than it is in the same latitudes on the continents. The explanation of this is, that the eastward velocity of the atmosphere over the oceans being much greater than it is on the continents, where it is obstructed more by friction and mountain ranges, the force driving the atmosphere from the poles toward the equator is less, and consequently the barometric pressure is less in the northern part of both oceans than it is on the continents in the same latitudes.

Upon the relative strength of the forces tending to drive the atmosphere from the poles towards the equator, depend the positions of the equatorial and the tropical calm belts. This force being strongest in the southern hemisphere on account of less resistance from friction and mountain ranges, the mean position of the equatorial calm belt is a little north of the equator, and the positions of the others a little farther north than they would otherwise be. The prime motive power also in both hemispheres being the difference of density of the atmosphere between the polar and the equatorial regions, arising from a difference of temperature and of the amount of aqueous vapor, during our summer, when this difference is less than the average in the northern hemisphere, and greater in the southern, these calm belts are forced a little north of their mean positions. Of course, just the reverse of this happens during our winter; hence we have an explanation of the annual variations of the positions of these belts.

In the case of cyclones the atmosphere at the earth's surface being forced in from

all sides towards the centre by the force arising from a difference of density of the atmosphere in the central and exterior parts, it cannot, on account of the deflecting force which has been explained, move toward the centre, without, at the same time, receiving a gyratory motion around that centre. Neither can it have a gyratory motion without also having a motion towards that centre, since in that case there would be no force to overcome the frictions of gyrations. Hence, neither the radial theory of Espy, nor the strictly gyrating theory of Reid and others, can be true, though either of them may be approximately so in special cases. But the gyratory part of the motion is not caused by the motion of the atmosphere from the north and south only toward the centre of the cyclone, as stated by Mr. Buchan and others, but equally by the different parts moving in from all sides, since, in whatever direction they move toward the centre, there is the same deflecting force, either to the right or the left, according to the hemisphere.

The motion of the atmosphere being in a spiral toward and around the centre of the cyclone, the deflecting force depending upon the earth's rotation, at right angles to the direction of motion, being resolved in the directions of the radius of gyration and tangent, the latter overcomes the friction of gyration, and the former causes a pressure from the centre, decreasing the height of the strata of equal pressure in the cyclone, and consequently diminishing the barometric pressure. The barometric gradient of a cyclone is estimated in precisely the same way as in the case of the hemispheres, using for v the lineal velocity of gyration obtained by resolving the real motion into the directions of the tangent of gyration and of the radius. It has been seen that a velocity of 30 miles per hour gives a barometric gradient of $\frac{1}{3}$ of an in. in 350 miles on the parallel of 50. A gyratory velocity therefore of 100 miles per hour would give a barometric gradient of 1 in. of mercury in about 300 miles. The velocities of gyration being known at all distances from the centre of motion, and consequently the barometric gradients, the difference of barometric pressure between the centre and the exterior, so far as it depends upon the gyratory motion, may be obtained by integration. The effect of the centrifugal force of the gyrations is generally only a very small quantity of a second order, in comparison with the other, and the effect of it is entirely insensible, except in the case of small tornadoes, when the gyrations are very rapid close around the centre.

In all the preceding estimates of the barometric gradient, it should be understood that the results belong merely to the force depending upon the earth's rotation, and to this must be added the part belonging to a difference of density of the atmosphere, which in the case of cyclones increases the gradient, but diminishes it in the case of the hemisphere. For the general motions of each hemisphere form a cyclone, with the pole as a centre ; but having the denser instead of the rarer portion of the atmosphere at that centre. Hence the motions in any vertical plane through the centre are reversed, and it becomes what has been called an anti-cyclone.

IMPROVEMENTS IN COAL-CUTTING.*

By Mr. W. HOOLE CHAMBERS.

From "The Mining Journal."

The number of patents that have been taken out for coal-cutting machines, and in connection with them, amounts, I believe, to considerably over 300. One great reason of failure was the employment of a motive-power which was neither economical nor beneficial. In a great number of cases the varying hardness of the holing, the changes in the nature of the roof, floor, etc., the various heights which the holing required to be in the seam of coal, the different depths of undercut required in various seams of coal in order to bring down the coal to advantage, and the necessity of having a machine which from one model could cope with all these various difficulties, have combined to prevent the success of many machines which

* Read before the Midland Institute of Mining Engineers.

had intrinsic value for one or other of these purposes, but which when applied to overcome others have signally failed. The motive-power best to be employed in coal-cutting machinery will, I believe, be acknowledged by all to be compressed air. It is easily procured; it is safe in use; the air is discharged into the mine fresh and pure at the working face; the average amount of air discharged by one of these machines will be 120 cubic ft. per minute.

It is not my intention in this paper to describe the machinery fully, as this has frequently been done, but briefly to notice some of the recent improvements which have brought the machine from one which had a substratum of excellence, but which by itself must necessarily have failed, to one which is a decided success. They are as follows:—1st. A solid forged frame to contain the machine, instead of a riveted one. This secures stability, and far less necessity for repairs.—2. Connecting-rods, instead of bevel gearing, for propelling the machine forwards. A much stronger and heavier machine can thus be made, and the attendant has much greater control over the machine.—3. The doubled-headed pick, having two or more cutting-blades on one shaft. This is a great advantage in coals which are liable to crush off the face, or where the roof is tender, as by going once over the face a depth of from 3 ft. 3 in. to 3 ft. 6 in. can be cut, which is quite as much as some coals will allow.—4. The curved pick, by which means the deeper the cut the less back room from the face is required in which to work the machine; thus, when cutting to a depth of 5 ft., only 3 ft. of back-stroke is required for the machine. —5. The successful application of loose points to the pick, perhaps the greatest improvement of all. Specification of Samuel Firth, No. 943, 1869, claims a loose point by preference, having a circular taper cottered into a socket on the pick-shaft, against a cushion of india-rubber or other suitable material.

Having thus briefly noticed the improvements lately made, I beg leave to bring before your notice the following table of experiments which were made at the Tingley Collieries of the West Ardsley Coal and Iron Company, on June 8 and 9 last:—

No.	Name of Coal.	Nature of Experiment.	Distance. Yards.	Time. H. M.	Depth. Ft. In.	Av. sq. yard per hour.	Per day of 9 hours.	Nature of Holing and Remarks.
1	Middleton main...	Single pick.....	10	13 10	2 3			
1	" ...	"	10	17 34	4 0	20	180	Usual bordway working, worth 7d. to 9d. per hour.
1	" ...	Removing machine	..	9 0	..			
2	" ...	Double-headed pick.	10	17 50	3 2	35	315	
3	" ...	Single "	5	8 5	2 3			
3	" ...	Removing machine	..	10 25	..	13	117	Very hard holing coal, working endway without any weight on.
3	" .	Single pick.....	5	9 10	4 0			
4	" ...	Double-headed pick.	5	25 0	3 3	13	117	"
5	" ...	Single "	5	16 0	5 4	12	108	"
5	" ...	No. 3 ex.....	..	27 40	..			
6	" ...	Single pick.....	5	17 0	5 0	13	117	"
6	" ..	No. 4 ex.....	..	25 0	..			
7	Little coal	Double-headed pick.	10	40 0	..	15	135	Medium between 1 and 3, standing some time, and much dirt fell.
8	Stone coal.....	" ..	5	23 0	3 0	13	117	Very hard stone and dirt intermixed.
9	" ..	" ..	5	37 50	3 0	8	72	"

In experiment No. 1, which was in the Middleton Main, or Silkstone coal, the bank was working broadway; it was 61 yards long, and about 1 mile from the pit bottom. The holing is done in the Baring coal in this seam, which is 1 ft. 3 in. from the floor. Experiments 3, 4, 5, and 6 are in the Middleton, or Silkstone coal, working endway; the bank having only just been opened, the coal is very hard. No. 5 experiment is over the same ground as Nos. 3, and No. 6 as No. 4; the steadiness of the machine on the road, and the beautiful regularity of the stroke in these two experiments were delightful to see.

In the Little coal the holing is done

close to the floor, the bank is working bordway of the coal, and a 3 ft. fall is as much as this coal will allow.

In the Stone coal the holing is done in the stone and dirt between two seams of Cannel coal; this was by far the hardest we encountered. Some idea may be gathered of the hardness, when I state that on an average it required 19 blows of the pick in the same spot before the full depth was reached, and sometimes as many as 21 and 22. It is far too hard to be done by hand-labor, but is the best part in the seam in which to hole.

We have before us 5 machines working in 3 different seams of coal, in one of which we have two species of work, all of which machines are doing well. The hardness of holing varies from comparatively easy holing, as in the Middleton or Silkstone coal, working boardway, to holing too hard to be done by hand, as in the Stone coal. This machine will, therefore, adapt itself to any hardness of holing; it can also hole at any height in the seam of coal which is requisite, by means of a false-bottom.

In the Middleton coal the holing is 1 ft. 3 in. from the floor, in the Stone coal about 5 in., and in the Little coal on the floor, and you have equal stability in either case. It can work in any seam of coal where 2 ft. of height can be secured, and only requires 3 ft. of room from the face in which to work; this is most remarkable where the depth of holing was 5 ft. 4 in., and only 3 ft. of room from the face required.

I would here briefly direct your attention to the reasons why, in many cases, where formerly powder was required to bring down the coal, by machine holing none is required. First, the weight of coal is left on by machine holing at the face, whereas by hand holing 9 in. at least is taken away at this point. Not only is this the case, but the line of gravity of the block holed is by machine holing brought much further forwards in the block of coal holed. By these two forces combined, if we take a block of coal 100 yards long and 3 ft. high, I reckon the power of separation will be increased by at least 40 tons, thus giving us an immense increase in the natural tendency of the coal holed to separate itself from the solid coal.

Before quitting the subject of the advantages of holing by machinery, I would point out those which are gained by the workmen. In the first place, the hardest portion of their work is taken in hand and successfully done for them; but what I regard as more important than the above is the immunity from accident from falls of coal which is offered. In the position which a man occupies whilst working the machine he is brought out of the groove which in hand holing he has to work under, and where he has neither inclination nor opportunity for examining the changes constantly taking place along the face of the coal. He can see in a moment any indication of the coal giving way, and is in such a position that he can easily get out of the way in such a case. The numerous accidents which occur to men whilst holing, from falls of coal, stamps this as a great advantage. The average length of life among our colliers is very short; no doubt this is partially due to the atmosphere they breathe being so thickly impregnated with coal-dust, and partially to cramped postures which have to be assumed in holing, sometimes for hours together. Immunity from the last is, as will be easily seen, insured by the machine under notice. The exhaust air is also so arranged that it blows the dust created in holing, away from the man who works the machine, leaving him in an atmosphere comparatively pure. You will see, then, that the advantage is not all on the side of the master, but is shared by those whom it is always our duty to consider in weighing the gains and losses of any important alteration like the present in the system and mode of working our coal; I mean the working colliers.

I have endeavored to lay before you in the foregoing paper, results which have come under my personal observation. I would not be understood to say that this is the best machine in existence, or that can possibly be produced; but I can say without fear of contradiction that every part of the machine is well and carefully considered, that strength is applied just where it is wanted, that the results obtained in the length of holing are better than I anticipated, and quite sufficient to prove it a decided success, and that no other machine has yet come under my notice which has succeeded as well as the above. In conclusion, I call upon you to give this subject your earnest consideration, for I hold that all these experiments, which are of so much vital importance to the coal

trade in general, demand our encouragement; and that where we find such patient study, such determination to overcome all difficulties, and such unremitting exertions as must have characterized the patentees of the machine under notice to have brought it from what it once was to its present state of perfection, we are called upon, having the interests of mining at heart, to give every aid in our power to the successful application of that which we cannot but feel is absolutely necessary to the full and cheap development of our coal-fields.

AERIAL FLIGHT, AS DEPENDENT ON MAN'S MUSCULAR EXERTION.*

By A. ALEXANDER, C. E.

From "The Mechanics' Magazine."

Very few of the methods which have been proposed, from time to time, for accomplishing aërial navigation have been submitted to anything resembling even a remote approach to practical tests; and hence, in the mind of each projector, there is a tendency to assume for his scheme a measure of success even in cases where this idea would be effectually dispelled by an actual trial.

If we put the balloon out of consideration, the different proposals made from time to time may be divided into two distinct classes—viz. (1), those in which the power necessary for flight is supplied by an engine actuated by steam, gas, or other similar agency; and (2), those in which the power is to proceed from the muscular exertion only of the flyer. In the first class it is assumed that man's muscular power will be insufficient to support flight beyond more than, at the best, a very short distance; and, in the latter class of plans, this power is obviously considered by those who approve them as adequate for flight of such duration as to be practically useful.

While the writer of these remarks must rank himself decidedly with the supporters of the former class, yet he is fully aware of the importance of avoiding any dogmatic views in a matter of which we as yet know so little; and he has, therefore, availed himself of some opportunities to examine various schemes for flight by muscular power, with the view of ascertaining their merits or defects.

Now, the detection and precise statement of any weak point in the reasoning by which a peculiarity of construction is defended, certainly comes next in importance to the suggestion of methods for actually accomplishing the end in view. By thus, as it were, clearing the ground, our time and means are not taken up, as they might otherwise be, in labors which will yield no satisfactory result. It is, therefore, thought to be desirable to point out to the members of the Society what is considered to be a fallacious mode of considering the action of certain apparatus for achieving flight.

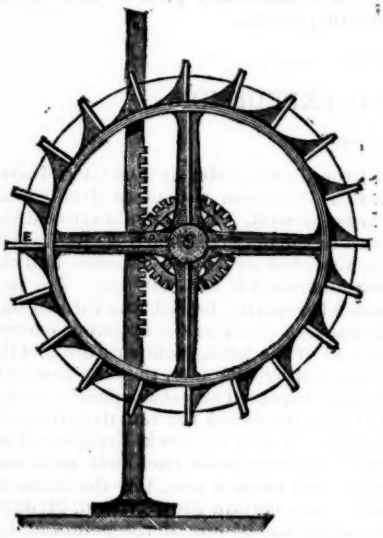
The writer has been led to this by his examination, at the request of our secretary (Mr. F. W. Brearey), of the plan and arguments brought forward by Mr. Craddock (whose ingenuity and valuable suggestions in other fields of mechanical inquiry seem often to have been appropriated without acknowledgment) for accomplishing flight by muscular exertion simply. Mr. Craddock had patented his plans in 1867 (No. 1,982), but the drawings more recently prepared showed a considerable improvement on the patented design.

It must be noted, however, that these remarks do not refer to any special apparatus, but exclusively to a special argument or point of view, by and from which such apparatus are justified, and their practical utility asserted. The reasoning by which the sufficiency of such apparatus was supported is as follows:

Suppose an upright metal rack A B resting on the ground at A, and gearing into it is a pinion C D, which is on the same centre or spindle as the wheel C E. This wheel is provided with steps round its circumference. The pinion C D being supposed to be kept in its place, and prevented from falling back out of gear by suitable guides, it is obvious that, were a man to place himself on the steps of the

* Read at the last meeting of the Aeronautical Society.

wheel, he would by its rotation elevate himself to any desired height. The apparatus, in fact, constitutes an ascending treadmill, and there can be no doubt that, with a break, provided upon the upright guides to regulate the speed, a man might mount in this way without difficulty.



"Now, here," say the advocates of the muscular system, "the man's force is, *with a suitable mechanism*, perfectly competent to raise himself to any given height, and that the air may take the place of the rack in this arrangement, it is only necessary that the *leverage be adjusted* to that end. It is a mere question of leverage; for we know that an extended surface, if moved with sufficient velocity, will sustain a reaction equivalent to the weight of a man. Let the leverage then be adjusted, but in the inverse direction, so that this velocity may be obtained from the man's motion, and he must rise just as he does when supported on the metallic staircase."

This mode of considering the matter is plausible, but it involves, I think, the fallacy of assuming the very point which is in doubt. It appears so evident that if a surface or surfaces be moved with sufficient rapidity, they will counterpoise the weight to be raised; and then, this being allowed, that a man will be able to raise himself on the rack-like support thus afforded, that one is apt to consider the rack as a *fait accompli*, in which case we can hardly avoid the conclusion that by its aid we may ascend to any desired altitude. But the fallacy here consists in assuming at all, without proof, the existence of the aërial rack, or, rather, in assuming that a man's force is competent so to move surfaces that an effective and effectual reaction may be obtained from them. With the form of illustration above explained, the mind is apt to dwell on the fact that the muscular power is thus shown to be sufficient, by appropriate mechanism, to raise the body, while it assumes that, as the intervention of mechanism involves no loss of power apart from friction, the conversion of the slow into the quicker motion required is a mere matter of mechanical detail. But it must not be forgotten that the muscular power has to effect two objects—1st, to produce such motion in surfaces sufficiently extended, that the weight of the body shall be counterbalanced; and secondly, to elevate the weight of the body upon the aërial rack thus produced. The first part of the business is precisely that which it is assumed has been done by drawing the rack on paper; but it is that which in fact constitutes the sole difficulty, and the possibility of which is denied by many.

Supposing it to be effected, we can easily see that the *ascent* of the rack, or the actual elevation, would require the most trifling addition to the force alread supplied; for if a certain mass be in perfect equilibrium in space, a very small force will, if sufficient time be given, generate any velocity required, the resistance of the atmosphere being excluded. Taking this resistance into account, it would still be true that a very small force, continuously applied, would suffice to generate a high terminal velocity. Returning to the rack illustration, if the radius C E of the path on which the man travels were to coincide with the radius C D of the toothed wheel, then evidently (apart from the weight of the apparatus) the man would be in perfect equilibrium; but a very small increase of the radius C E would suffice to produce an upward movement and relatively downward movement at E of the revolving platform, so great that a man's speed would be unable to keep up with it. No just inference can, therefore, be drawn from reasoning founded upon the ease with which muscular exertion would enable us

to rise by means of such a revolving platform as that which has been described; for, to assume the possibility of any reaction from the air due to the muscular force expended, and akin to that afforded by this platform, is to assume the very point at issue. The writer, while far from wishing to discourage inquiry on the part of those who may think otherwise, has long been of opinion that man's muscular exertion will be found in all cases quite inadequate to maintain any such reaction for more than the shortest space of time, and that to accomplish aërial navigation in a comprehensive sense we must obtain a proportion of power in relation to weight considerably greater than we at present possess.

M. JANSSEN'S AERIAL EXPEDITION.

From "Engineering."

M. Janssen has furnished to the Academy a report of the aërial voyage which he undertook on the 2d of December, 1870, to join the expedition to Algeria for observing the eclipse of the sun on the 22d of December. The learned astronomer, wishing to pass the lines of the Prussians without soliciting permission of the enemy, decided to take his route through the air. In the absence of any experienced aëronauts, he himself undertook the command of the Volta, and quitted Paris on the 2d of December, at 6 A. M., from the Orleans Station, accompanied by a marine named Chapelain. The Volta had 2,000 cube metres capacity, and, although hurriedly made, offered sufficient guarantees of stability and strength. It carried an equatorial parachute formed of a band of stuff 3 ft. wide, running round the centre of the balloon, fixed on the upper side, and bound on the lower side by cords to the lower part of the balloon. Inflated with ordinary gas, the Volta had a rising force of 3,080 lbs., divided thus:

Weight of the balloon complete ..	1,144 lbs.
Instruments.....	352 "
Two aëronauts.....	330 "
Ballast	1.254 "
	3,080 lbs.

The instruments were reduced to their essential parts, and were to be completed at some large town on the route. These delicate pieces of mechanism were carefully packed in boxes, arranged so as to resist violent shocks. On departure, the astronomer judged that he was taking a southerly course. Ballast was thrown out, so that the line of investment might be passed at a minimum height of 3,000 ft. At 7.15, the barometer stood at $25\frac{7}{16}$ in., and the thermometer at 30.20 deg. Fahr., and the direction was more decided towards the west. The balloon crossed the Eure to the north of Chartres. At 7.35 the sun rose, the air cooled rapidly, and the thermometer fell to 19.40 deg. The balloon fell rapidly; ballast was thrown out. M. Janssen explains the apparent contradiction of the falling temperature and the rising sun by the fact, that the first rays of heat dispersed the atmospheric vapors, and thus increased the radiation from the balloon. Up to 8 o'clock, the effect of the solar radiation made itself felt more and more; the balloon rose, the thermometer fell. To ascertain the direction, M. Janssen made use of one of the points of the anchor suspended to the car. This point traced on the ground a line easy to follow. It was enough to align one side of the compass box with this direction, to know the angle made by the route with the magnetic meridian. At 8.17, the direction was east, quarter south; the temperature was slightly raised, the weather magnificent. It was perfectly easy to make all observations, although the speed was 50 miles an hour. At 8.48 the balloon passed to the north of Mans. The town lay stretched out below so clearly visible in all its details, that it would have been possible to take of it photographic pictures. At 9.45, the balloon attained an elevation of 6,000 ft.; the barometer marked only 23 in. This elevation was due to the heating of the gas. At 10.40 it descended, the exterior air beginning to heat faster than the gas in the balloon. The barometer indicated 33.80 deg. The travellers passed over Château Gontier, whence a confused noise of acclamations was perfectly audible.

At 11.15, the astronomer saw that they

neared the sea; it was necessary to descend without losing an instant. The valve was opened, and the barometer rose from $23\frac{5}{16}$ to $27\frac{9}{16}$ in.; it was a vertical fall of 4,500 ft. The valve was closed, and ballast was cast out, to reduce the velocity of the descent. The fall thus checked, the balloon rose a little, and a height of 1,200 or 1,500 ft. was maintained. Again, the descent was accomplished to within 600 ft. There remained the final fall, always difficult and dangerous, but which, in this instance, promised to be accomplished under favorable conditions. Opening the valve, M. Janssen caused the balloon to descend, and a sack of ballast being thrown out, a height of 150 ft. was preserved. The guide rope was then cast over—a long, heavy cord of 600 ft.—which, by its trailing along the ground, served as a brake. As soon as this rope struck the ground, it produced an ascensional undulation, followed by a soft and very oblique descent. Suddenly they neared a church steeple, which they cleared with a bound by throwing out a bag of ballast. The balloon then followed across land intersected with hedges. The marine threw the anchor, and opened the valve, but the anchor broke, and, after an instant, the balloon gathered speed, breaking through hedges and trees. At last the speed decreased, thanks to the friction of the guide rope, which was seized by the peasants, and the adventurous travellers landed safely with all their instruments near St. Nazaire.

M. Janssen continued his scientific journey without further trouble. The voyage of the Volta proves the possibility of transporting, by the aërial route, heavy and delicate instruments. It is, moreover, especially interesting from the point of view of the physical atmospheric question. The study of this question will prove of much value in aërostatic observations.

STEVENS INSTITUTE OF TECHNOLOGY.

In number 33 of our current volume, we gave an engraving representing the exterior of the new School of Science and of Mechanical Engineering, now open at Hoboken, N. J.

The Stevens of Hoboken have been known for three-quarters of a century past, as active, intelligent and successful engineers.

Col. John Stevens began about 80 years ago to experiment with a view to the introduction of steam in the propulsion of vessels, and showed his remarkable genius by, at that early day, setting afloat a twin screw steamer with a tubular boiler, which he ran on the North River in 1804. The machinery of this boat is carefully preserved, and is given a prominent position in the model-room of the Stevens Institute of Technology.

Another boat succeeded, the Phenix, which came out simultaneously with Robert Fulton's boat, the Clermont. Still later he turned his attention to the use of steam on land, and, even before Robert Stephenson had commenced his now famous work, Col. Stevens planned and described almost precisely a prototype of the modern locomotive, and, predicting with wonderfully accurate prophecy, its great work and the limits of its powers, applied himself with characteristic energy to secure its introduction nearly 20 years before its success became a generally known fact.

Dying in 1838, at the advanced age of 89, Col. John Stevens left behind him sons well worthy of such a sire, and the inventions and the engineering of Robert L. Stevens are as well known to engineers as were the achievements of his father. He introduced hollow water lines in the Phenix and feathering paddle-wheels in 1809, used steam expansively on the Philadelphia in 1815, and put the now universally used skeleton beam on the Hoboken in 1822. He strengthened the North America with a "hog frame" in 1827, adopted return tubular boilers in 1832, steam packets pistons in 1840, the Stevens Cut-off, designed by himself and a relative, F. B. Stevens, in 1841, anthracite in locomotives in 1848, and many other equally valuable and remarkable advances in mechanical engineering were due to R. L. Stevens.

The celebrated "Stevens Iron-Clad" was one of the most remarkable of this great engineer's projects, and, with its great size and fine proportions, its iron

hull, its athwart ship bulkheads, its double bottom, its independent twin screws, and its return tube boilers, it stands to-day, a most formidable war vessel, and an appropriate monument to its talented designer.

Another of the sons of Col. Stevens, Mr. Edwin A. Stevens, was also a man of great constructive talent; and in carrying out the designs of his deceased brother, as well as in independent labors, he exhibited the same "Stevens ingenuity," energy, and intelligence.

He, however, has erected even a nobler memorial than did his brothers, or even his father. His last and posthumous work is a fitting monument to himself and to the family.

By a provision of his will, a square in the city of Hoboken was set apart, and the sum of $150,000 was appropriated to put up a building to be devoted to educational purposes, and a further sum of a half million dollars was to be invested as a permanent endowment with the income from which the regular expenses of the school were to be met.

The trustees, Mr. W. W. Shippen, Rev. S. B. Dod, and the widow, Mrs. E. A. Stevens, have bravely carried out the noble plan sketched for them.

The institution with peculiar appropriateness, as well in view of the bent of its founder's genius, as in compliance with the now fully recognized and earnestly proclaimed needs of the time, has been planned as a School of Mechanical Engineering and of Applied Science, and its courses of instruction—while omitting no part of the usual scientific courses of our colleges, and, indeed in its physical laboratory going far in advance of the usual college course—are all so directed that the student will find in all of them essential aid in, and preparation for, his professional course.

Beginning our description with the lower portion of the building, we find in the basement at the western end, a large room containing two large boilers for heating the building, and supplying steam to drive the steam engine. It also contains the furnaces required in the metallurgical department of the chemist's technical course. At the opposite end of the building we find a pair of steam engines which drive the machinery of the machine shop. The machinery and tools are carefully selected, and of the best materials and workmanship. A pattern maker's and a machinist's bench are placed here also, and all of the smaller wood and iron working tools.

Partitioned off from the shop by a neat metal screen, is a space containing a furnace for supplying oxygen, and also tanks for retaining both oxygen and hydrogen, under the pressure requisite for the successful use of the oxyhydrogen light and blow-pipe. From these tanks pipes lead to all the lecture-room tables.

The basement also contains several store-rooms, a glass grinding-room, and a battery-room, where the large Voltaic batteries are kept, and under the west wing are the assay-room, and the apartments of the Janitor.

Passing up stairs and turning into the west wing, we find its three floors entirely devoted to the Department of Chemistry.

On the lower floor is the working laboratory, where analyses of ores and other minerals and materials used in the arts may be tested and valued. On the second floor is the lecture-room, neatly fitted up, and supplied with every convenience that ingenuity could suggest and art could furnish, and, on the upper floor, are a mineralogical cabinet, Professor Leeds' private room, and a laboratory in which to carry on his own independent researches.

Returning to the main building, first floor, we enter at the western end, the library and model-room. Here are a considerable number of book and model cases, all of which contain much that is of interest.

The library is intended to be purely technical, and to be very complete in works relating to mechanical engineering. The models placed here are generally those of unusually popular interest, and, when the orders given abroad are filled, this room will be a museum of great attractions.

Here is the old engine built by James Watt, for Col. John Stevens, with its tubular boiler and the twin screws just as they were designed by the last named remarkable man, and as he used them sixty-seven years ago. Here are models of the great "Stevens Battery," the first effective design of iron-clad ever proposed, and constructed; here are steam engines, pumps, regulators and water wheels, and many kinds of machinery.

Here is the great "Inductorium," capable of sending its lightning-like spark 21 in. through the air, and *through glass 3 in. thick*, and pieces of glass thus pierced lie on the shelf above it.

Here is a Scott "Phonautograph," which reduces audible sound to a legible character, and with it large numbers of interesting and curious acoustic apparatus; here are probably the largest selenite objects in the world, displaying their wonderful changes of color under polarized light; here are Professor Mayer's neatly fixed "Magnetic Spectra," displaying the lines of magnetic force as they actually exhibit themselves over the magnet.

Here is also a little brass model and lithograph, exhibiting John P. Taylor's armored torpedo boat of 1845, probably the first armored torpedo boat ever designed.

But, interesting as they are, we cannot attempt to fully describe these collections, for much of equal interest is found elsewhere.

At the eastern end of the building, and on this floor, is the Physical Laboratory, which is placed under the care of Professor Mayer. The room is as large and as finely lighted as the library. Here we find ten alcoves, separated from each other by apparatus cases, each being devoted to a single class of work. One alcove is devoted to electrical measurements, and its case contains a set of splendid apparatus made by Elliott, of London; another is devoted to optical researches; still another to the investigation of the laws of heat, and another to molecular physics; and each is supplied with a complete set of the needed apparatus.

Here is mounted the largest electromagnet in the world, weighing nearly a ton, and capable of supporting many tons of iron; here we find apparatus so delicate as to be capable of indicating the changes of dimension produced by magnetizing an iron rod, and even of measuring their amount, by the movement of a spot of light reflected upon the wall. Here are delicate thermometers, fine metric and other measures of space, barometers, spectroscopes, and all those other curious and wonderful pieces of apparatus with which our wonder-exciting friends, the physicists, are astonishing us daily.

And here the student is expected to work until he has become as familiar with the apparatus for determining the physical properties of the useful metals, familiar objects, and elements and forces, as he has been made, in the room below, with the tools of wood and of metal workers.

We have time to take a mere glance here, and we pass up to the second floor.

At the east end, we find a pleasant, well-lighted lecture-room, stocked with apparatus, and occupied by President Morton in the prosecution of his own scientific labors, and intended, also, to be used as his lecture-room in the subject of *theoretic mechanics*. Large drawings of a section of the Giffard injector, and of other machinery and apparatus, hanging on the wall, indicate that he proposes to adopt unreservedly the "technical method," illustrating his theoretic teachings by technical problems and exercises.

Here he devises the brilliant experiments that, with the more brilliant lectures that they illustrate, have delighted so many intelligent audiences.

The next room is the lecture-room of Prof. Mayer, and is devoted to instruction in physics.

The lecture table is completely fitted up like the others, with pneumatic trough, illuminating and oxygen and hydrogen gas-pipes leading from the tanks in the basement; fixed wires from the battery room, and a "vacuum pipe" leading to a plate fixed upon the table from the Bunsen air-pump, so that a vacuum may be *turned on*, like the gas, by turning a cock. Professor Mayer's study is next door (No. 15). The Professor has evidently a mechanical bent, as we find in his room a neat Stewart lathe and a work-bench; and, in his cases, many samples of his workmanship, in the form of ingeniously contrived apparatus used in his magnetic and other investigations in physics.

In Room 14, directly over the main entrance, is the optical cabinet, which contains the celebrated Bancker collection from Philadelphia—a most interesting as well as large collection. When this is supplemented by the additional apparatus ordered at home and abroad, it will be, by far, the most complete outfit of optical apparatus possessed by any institution in the world.

Room 13 is the study of Professor Thurston, the head of the Department of Mechanical Engineering. The fine photographs of locomotives and other pictures

of machinery, ships and iron-clads hanging on the walls, and the collection of models and drawings, and the mechanical curiosities lying about, indicate that our mechanics, manufacturers, and inventors already see, that by aiding the Professor in his work they still further assist themselves.

Room12 is Professor Thurston's lecture-room, a fine, large and lofty room, probably 35 ft. square. Along one side extends a great case (for models) of black walnut, and of neat design, which is rapidly filling with models of various kinds of machinery, made both at home and abroad.

Among the models already received, is a beautiful pair of oscillating steam engines, with feathering paddle-wheels, just as they were fitted in so many blockade runners during the war, complete in every detail, and beautiful in finish and workmanship.

Another is a model stationary engine, of 1½ in. diameter of cylinder, and 4½ in. stroke, made by the Professor when a schoolboy, with boiler and Greene's "drop cut-off" complete, even to the details of its little "fly-ball regulator." It is hoped that our steam engine builders will make this collection of engine models very complete.

Here is a beautifully finished Giffard injector, with all its appurtenances, cut open to show its interior construction—a contribution from Sellers & Co., of Philadelphia; here is a silver-plated model of Mr. John F. Ward's spherical water-pipe joint; here are steam engine indicators, gauges, rail fish joints, a model brick-making machine, and still room for the large collection of models of simple machines and elements of machines ordered from Darmstadt, Frankfurt, Paris, and in our own country.

At the side of the room, opposite the model cases, is a long table, fitted with over 30 drawers, for working drawings of machinery. Some very valuable contributions have already been received, and others are coming from our enterprising and liberal manufacturers. One drawer contains over 60 drawings—a complete set—of a marine engine of 1,000-horse power, from Mr. Geo. B. Whiting, chief draughtsman of the Naval Engineer Department; and another contains a set of tracings of an inclined engine of 60-inch cylinder and 10-feet stroke, also from the private collection of the same gentleman. Other drawers contain drawings from other generous contributors, and sets purchased in Europe; and still other drawers are depositories for the private collections of the Professor.

Additions are frequently being received, and others promised by friends of the good cause.

We ought not to forget to mention the numerous drawings which exhibit the progress of the Stevens iron-clad, from its inception to the present time. On the wall, among other pictures, is to be noticed a drawing of a Babcock and Wilcox boiler, which is a very remarkable specimen of fine work with the drawing instruments.

Many rooms remain to be described, but our space will not admit, even were they of equal interest to our readers, a detailed description of the mathematical department, the drawing rooms, the photographic and photometric rooms, and the workshop of the instrument makers to the Institute. The Institute and the latter gentlemen—Messrs. Hawkins and Wale—are equally fortunate in effecting an arrangement such as that which, a century ago, at the University of Glasgow, resulted in the grand series of inventions of James Watt, the mathematical instrument maker to that college.

In a succeeding number, we will endeavor to find space to describe briefly the proposed course of instruction at the Stevens Institute of Technology.

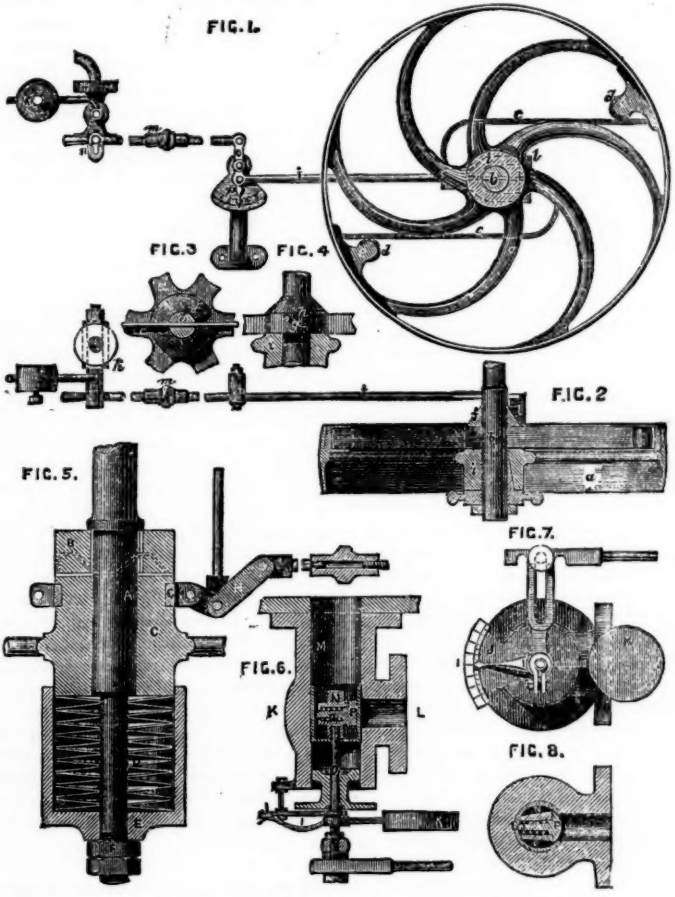
THE new line of tramway laid down from Brixton to Kennington was opened lately for public traffic. Large and convenient carriages on low wheels continue to run over the metals, and conveyed good loads of passengers each journey. The vehicles are capable of carrying 46 persons, one-half inside, and the other half on the roof of the carriage. The fare is two pence either way. The omnibus fares have been reduced to the same figure. The tramway to Clapham is now in course of construction, and will be united with the Brixton line at Kennington, and then continued to Westminster.

OUDEMONS has succeeded in making an alloy of zinc and iron. The new metal, which contains 4.6 per cent. of iron, is remarkable for its whiteness and tenacity.

GAUTREAU'S DYNAMETRICAL GOVERNOR.

From "Engineering."

We here illustrate an arrangement of "dynametrical governor" designed, and patented in this country, by M. Jacques Théophile Gautreau, of Paris, and which is intended for use either as a dynamometer, or as a governor for regulating the supply of steam to an engine according to the amount of work that engine is actually performing. The construction of the apparatus can be best ex-



plained by reference to the engravings which we annex. In the arrangement shown in Figs. 1, 2, and 3, the driving wheel, *a*, is loose on the shaft, *b*, and rotatory motion is transmitted to it by means of a spring, *c*, which is formed of a blade of steel, and passes through the shaft, *b*, to which it is thus firmly secured, the curved ends of this spring acting on rollers, *d*, which are carried in bearings, *e*, cast in one with the pulley, *a*. The angular displacement which may thus be produced between the wheel, *a*, and the shaft, *b*, is transmitted to the throttle valve by a boss, *f*, fitted so as to move with but little friction along the shaft, *b*,

and recessed in order to admit of the spring, *c*, passing through it, by which means it is caused to turn with the shaft, *a*, whilst at the same time it is free to move longitudinally along it. The boss, *f*, has formed on its periphery a helicoidal groove, *g*, in which a pin, *h*, works, which pin is carried by a projection cast in one with the boss, *i*, of the pulley, *a*. By this means any displacement of the pulley in relation to the boss, *f*, produces a corresponding linear displacement of the latter in the direction of the centre of the shaft, *b*. This linear displacement is in its turn transmitted to the rod, *j*, which actuates the steam inlet cock, *k*; for this purpose the boss, *f*, is provided with a conical surface on which an inclined abutting piece, *l*, slides, which is maintained between the bifurcated extremities of the rod, *j*.

In order to facilitate the regulating of the engine the rod, *j*, is provided with a screwed socket, *m*, which admits of the length of the rod being varied, and the original position of the cock or sector, *k*, being determined, the plug, *n*, of the cock is also furnished with a slot in which a button on the end of the rod, *j*, is capable of moving, by which means the opening of the cock for a given amount of linear displacement of the rod, *j*, may be varied at will.

In order to utilize the apparatus as a dynamometer, it is simply necessary to interpose on the rod, *j*, a lever, *o*, provided with a hand or pointer, *p*, to move over a divided dial or quadrant, *q*. By this means the amount of motive power transmitted by the engine may at each instant be ascertained, and the relative proportions of the two arms of the lever, *o*, co-operate to determine the admission of steam to the engine in proportion to the tractive strains which the driving belt has to overcome.

Figs. 4, 5, 6, and 7 illustrate another type of governor which differs from that herein before described, in that the blade springs are replaced by disc springs, and that the rectilinear displacement which has to act on the valves is obtained on the driving wheel itself. This arrangement, therefore, is not applicable to where gearing is the medium used for transmitting power, but simply when a belt and pulleys are employed. B is a collar which is fast on the shaft, A, and is provided with a series of teeth or inclined planes corresponding to similar inclined planes cut on the boss, C, of the driving wheel; the boss, C, which is loose on the shaft, A, is maintained against the collar, B, by a series of disc springs, D, disposed around the shaft, and enclosed in a box, E, the position of which is adjusted by means of the nuts, F, which determine the degree of tightness of the springs, D. The effect of this arrangement is that when any variation takes place in the strain transmitted by the belt, the springs, D, bend, and the oblique teeth of the boss, C, engage more or less with those on the collar, B; the position of the driving wheel on its shaft is thus changed, and this variation is transmitted to the valves by means of the collar, G, and the cranked arm, H. In this type of governor, as in the preceding one, an indicating hand or pointer, I, moving over a dial or quadrant, J, is employed for the purpose of indicating at each instant the amount of motive power transmitted by the engine, and a counterweight, K, is provided, which has a constant tendency to bring back the driving wheel to the required position when a change in the deflection of the springs, D, takes place.

The description of valve which it is proposed to employ with this system of governor, is shown in Figs. 5, 6, and 7. It is composed of a brass box, L, fixed in the interior of the steam pipe, M, in which moves a piece, N, actuated by the rod, O, which carries the indicating hand or pointer, I, and the counterweight, K, and actuates a cylindrical closer, P, intended to more or less cover the aperture through which the steam enters the slide valves. In order to compensate for the wear which may take place during the working, the cylindrical closer, P, is constantly maintained against the inlet aperture by means of a helical spring, Q, which is disposed in the interior of the piece, N.

The cultivation of the tea plant promises to become a source of wealth to California. The tea plants, which already number 300,000, are doing well. One of the clearest burning oils—China oil—is extracted from the tea nut, and enchances the profits of tea culture. The Chinese and Japanese immigrants supply suitable labor for the new plantations.

CHINESE AND JAPANESE ART, AND ITS IMPORTANCE FOR MODERN ART-INDUSTRY.

By JACOB FALKE.

From "The Workshop."

Eastern Asiatic art was formerly diligently sought after and highly prized in Europe, and in the *Rococo* age, especially in the first half of the 18th century, it exercised great influence in our decoration, our Art-Industry, and our taste, which it helped to metamorphose, and to which it gave a character of bizarrerie peculiar to the *Rococo*. Numbers of amateurs then formed collections, such as the Japanese Museum in Dresden; the palaces of the wealthy had their Chinese cabinets, the dwellings even of private citizens boasted many Chinese ornaments; in a word, China and Japan were the fashion.

At the present time it is far otherwise. In comparison with the general estimation they enjoyed in the former century, the art productions of these countries are fallen into open discredit. Art-History, which in the time of the *Rococo* had no existence, takes no notice of them; private houses know them no more, or at most only in Holland; amateurs have become rare, though the collectors who still affect them are by no means of the most contemptible class, and some even rank among the most discriminating friends of Art.

It must be confessed too, if we wish to be honest, that this discredit is apparently not without good reason, and must have been a necessary consequence of the progress of taste. In the first place, Chinese and Japanese Art deteriorated essentially during the last century both in taste and workmanship, so that the ordinary new patterns which came to us, and indeed still come to us from those countries, seldom deserve any special consideration. In the next place, the forms of their vessels and other articles, no less than the ornaments, are most extravagantly bizarre in their design, so that a taste which had been formed by the observation of antique works of Art, or those of the Renaissance, and which was not able to overlook those deficiencies and to appraise the other sides of artistic and decorative beauty, would of necessity be repelled from them. And this must have been the case at the end of the former and the beginning of the present century, when the revival of the Antique during the French Revolution and the Empire suppressed all other forms of Art, and discarded all other taste.

Yet, nevertheless, this Eastern Asiatic Art, when examined with that critical eye which can discern the wheat from the chaff, and which does not look to it for that which it does not possess, but only regards its peculiar beauties and excellencies—nevertheless, I say, it offers sufficient artistic peculiarities to merit, for their sake, the consideration of the friends of Art of the present day, and to be a useful adjunct to any museum or institution devoted to that practical æsthetic object, the elevation of taste and of modern Art-Industry. It is from this point of view that we would proceed in the present article, to glance at Chinese and Japanese Art, its peculiarities, its beauties, and its excellences.

It is commonly supposed that those qualities which are at all worthy of consideration for modern Art-Industry consist solely in special workmanship, as for example, the excellence, solidity and lustre of the lacquer work and polish, to which our artists cannot in any degree approach. But so exclusive an opinion is assuredly a mistake; the artistic work of the Chinese and Japanese—by which we intend the productions of Art-Industry, and not their pictures or purely plastic works—have positive æsthetic peculiarities which demand recognition. We must only take care not to look upon the object as a faultless piece of work according to æsthetic principles, as pure in form, design and ornamentation; we must consider that this or that determinate creation, this or that determinate figure, was partly owing to their histories and tradition, partly to their civil and religious laws, under pressure of which the artist was obliged to bend. We must conceive of these works from the point of view of decoration, we must try them by the effect which they produce as a whole, and by the way in which they harmonize with other works of Art. We may then go farther, and shall find much that is charming and attractive in the details and peculiar structure of their creations, if

only we do not expect these advantages in the very first object that meets our eye.

Considered under this decorative point of view, those artistic productions of Eastern Asia, even the most modern and the most common, never appear without harmony in their coloristic effect, never glaring and hard in their tints, a defect which till of late, and even now is so general in modern Art-Industry. The newer Chinese works may often be liable to the reproach of paleness and feebleness of color, which, however, is not always a defect; but the composition is always correct, and the effect pleasant to the eye. This is a quality which deserves to be well considered by the Art-Industry of the present day, and which in its time the *Rococo* well understood how to turn to advantage. But if we separate the really good from the common and poor, which the Chinese, as a rule, sent to us as good enough for "the Barbarians," and if we fix our attention especially on the more ancient objects of Art, to whatever branch they may belong, we shall be obliged to acknowledge their positive excellences. Instead of that mere harmony which appears frequently to be a purely negative excellence, we shall come upon effects of color which are most admirable, full of glow and depth, quiet and sober, yet still rich and elegant, which would do honor to any time and any style of Art, and which are highly to be recommended for study and imitation. We shall find also a quantity of originally shaped vessels, which just as they are, or perhaps with only and slight alterations, would be suitable for our modern use and even satisfy a delicate perception of form; and lastly, even in the ornamentation, in the conventionalizing of the flowers, for example, as found in the more ancient works, we shall discover motives which may be useful for decorators of the present day. We put on one side the workmanship, which is partly lost even to the Chinese themselves, but which might be most advantageously revived.

In order to commence at once with the greatest excellence of the Chinese productions, we had especially in view, in intimating the above-mentioned effects of color, their older copper vessels with cloisonné enamel, which are now to be seen in many modern collections, and particularly in private possession. They are altogether absent from more ancient collections, because, being most highly esteemed by the Chinese themselves, they were seldom exported from their own country, but were almost always carefully hoarded in the royal palaces of Pekin, and it is only since the taking of that city by the French and English, and the consequent pillage of the palaces, that they have come to us in any quantity, so that they continue to maintain a high value.

The Chinese enamel has taken pretty nearly the same development which the history of this branch of Art shows to have taken place among ourselves, at least in its three principal forms. These are, 1. The cloisonné enamel; the enamel that is enclosed in cells or compartments by gilt bands of metal forming the outlines; 2. The champlevé enamel, in which the metal plate is chased out like a wood-cut, the cavities filled with enamel by means of fusion, and the lines of metal polished and gilt; 3. The enamel painting on plates covered with enamel of one color. These three forms, considered together, follow one another in point of time, but instead of showing any progress, they are marked by decline. The painted enamel, which is now almost always, and with very little solidity, used on their copper vessels with a dark blue ground, possesses on the whole but few charms. The best among them are plates and saucers of solid copper discs, covered with a rather thick white enamel, which is painted with flowers and ornaments, some of which are very neat, and of good style and disposition. Of the same kind are also whole tables and entire sets of articles for the toilet, which, however, only appear as abuses of the material and workmanship. Still the best and oldest specimens of this kind, though in fact they are but imitations of porcelain, are worthy of attention for museums and collections as well as for Art-Industry.

Of far more importance are the Chinese champlevé enamels, the production of which is especially to be attributed to the sixteenth and seventeenth centuries. These are not of copper, but bronze, destined for the altars in the houses of the nobles, and therefore of rare occurrence. They resemble the Renish and early Limoges enamels of the twelfth and thirteenth centuries in workmanship and coloristic effect, but the forms and ornaments are in

the manner of the *Rococo* style, and therefore seldom of use to us. Far higher in both respects stands the earliest kindof the above-named cloisonné enamel of the middle ages. To this period, at least, belong the finest and most important objects; among them are some of great height, reaching even to 3 ft., and surprising specimens of freedom from those eccentricities which in some way or another usually characterize the art-productions of the Chinese. Many of these have been arranged by amateurs as lamps, while others as basins and flower pots form the charming ornaments of artistically arranged dwellings. Their chief excellence consists in their wonderful depth and richness of color, especially of a dark red, which the enamel manufacturers of Europe have never been successful in obtaining. The design, too, of these ornaments is seldom wild and capricious; at times naturalistic with splendid flowers, but frequently conventionalized somewhat after the Romanesque treatment. Such qualities, as soon as these vessels were brought to light, attracted the attention of French and English bronze manufacturers, but their imitations fall very far short of the originals in their artistic effect. The French imitations especially, which were to be seen in great numbers so early as in the Exhibition of 1867, have the one great fault of allowing too much space to the gilt bronze surfaces, so that the enamel is almost smothered, while it never attains the depth and strength of Chinese coloring. The effect they produce is merely that of dazzling the eye, they have no real elegance, and are quite destitute of the wonderful repose and harmony of the originals. In porcelains, too, the effect of their coloring has been attempted, and this not unsuccessfully, a proof how useful the study of them might be for modern industry in more ways than one.

Of still more importance, because of more general application, is the study of the Chinese bronze works. Their forms, indeed, even in the more ancient vessels are for the most part of the *Rococo* style, but their treatment is thoroughly admirable, and so perfect in cast and chasing, and so highly wrought, that they are perfectly wonderful. Added to this, we must note the varied tints and colors which the Chinese succeeded in giving to their bronzes from the darkest black and green brown to red and gold, a treatment of the surface which has confessedly given the impulse to a similar kind of bronze manufactures among the French. Moreover, the Eastern Asiatics, and especially the Japanese whose works in metal far surpass those of the Chinese of the present day, are acquainted with the art of silver damascening and practise it with surprising skill. Their bronze vessels, covered all over with ornaments of inlaid silver threads, which unfortunately seldom reach to us, because they do not belong to the usual articles of commerce, excite the admiration of connoisseurs, not only by the beauty and perfection of their workmanship, and their comparatively small price, but by the originality and energy of their composition. It is the same with works of a similar character in which the silver is not inserted in threads into the smooth surface, producing its effect by the design, but lies in high relief, forming ornamental patterns and figures which are composed and chased with all the boldness of Japanese art. The steel of their arms knives, and numerous small articles, is treated by them in the same manner. All these pieces of workmanship, so rife with instruction, are hitherto only to be met with in the possession of amateurs and private persons, and very seldom in public collections, in which are kept so many objects destitute of any artistic, any real value, but whi h have had the fortune to have seen the light so many hundred years ago instead of only yesterday.

The case is different with the Chinese and Japanese porcelain manufactures, the fame of which dates many centuries back, and which, by zealous imitation and the incitement of gain, for more than a century and a half, have given rise to a splendid and even flourishing and extending branch of industry. Our European porcelain is indebted for its origin, both as to art and material, to the Asiatics; only it has quitted the path which was æsthetically placed before it, and that not entirely to its advantage. This is the case, for example, with the color of the material and the material itself. The European porcelain very soon after its discovery made every effort to produce a material as purely white as possible, and the great manufacturers have by degrees succeeded in this point, which now offers no longer any difficulty. But it is a question whether

this is really an advantage, and not rather a sacrifice to the artistic side of the manufacture. The porcelains of China and Japan have never had this tendency, and if now, much of the Asiatic has almost or altogether the whiteness of the European, this is owing to the Chinese yielding to the taste of the Europeans in the way of business. The genuine, good old Chinese porcelain is always in the material itself slightly colored, either with a greenish or bluish tint, and this is one great reason why all these works possess a far greater degree of coloristic harmony. The purely white porcelain is in itself of no decorative quality, and if ornamented with color, the effect becomes hard and stiff. This is a point to which attention cannot be sufficiently directed, until it enters heart and soul into our present manufactures.

But this is not the only point for the sake of which we wish to turn the attention of our artisans once more to the porcelains of China and Japan; there are still a number of points of view and specialties on account of which they recommend themselves to our consideration. I grant that there is not much beauty in the ordinary articles of commerce, though some of them do possess considerable charms, or in many peculiar productions which amateurs hold in high esteem ; but when we go through such collections as that of the Japanese Museum in Dresden, either cursorily or with an attentive and intelligent eye, we cannot but be astonished at the multitude of variegated and happily executed ornaments, with which no modern exhibition, not even such as Sevres could produce in the last 10 or 20 years, can in any degree compete. It is of course, impossible for me here to go into any description, or even notification of the different kinds of decorative treatment ; I will only mention one, the simplest and perhaps the most appropriate of all, but which in our day has been almost entirely forgotten. I mean the blue china. Esteemed above all other in China and Japan for many centuries, it was very successfully imitated by us, in the 17th and the beginning of the 18th century, and but then, in consequence of the facility with which the porcelain received other colors, it fell into discredit. Yet, for the dinner table, which on account of the richness of its other appointments, cannot bear too much color, there is no better ornament, and it becomes one of the most charming decorations of a well-appointed dining-room, as is well known to amateurs and virtuosi, who are never tired of adding to their collections of blue porcelain or fayence.

In form, too, though at the first glance they appear of the *Rococo* caste, the Chinese porcelains are by no means to be despised. They even have more claims on our attention, inasmuch as our tea-services now in general use, derive their origin from them, and cannot deny their relationship, though it may be somewhat distant. In the mean time our artists have endeavored during the last 150 years to design and shape them in accordance with the prevalent style and the fashion of the day without effecting any improvement, and now, indeed, we hardly know what to make of them. It would not therefore be perhaps quite inappropriate, if we for once recognized their origin, for these old Chinese-Japan tea-services often display very agreeable forms and a physiognomy altogether original. It is the same with many other articles which might be rendered serviceable for ourselves if only an intelligent hand were to take them up, which thoroughly understood where and how to alter them.

There is one more branch of Eastern Asiatic Art ,namely, the lacquered work, which appears less directly applicable for our use, partly because it consists for the most part of articles of luxury, and partly because the distance between it and the European manufacture is too great ; and yet perhaps this last circumstance might only be a reason for our museums to collect specimens of those lacquered works, many of which are of really classical delicacy and execution. In what can all our tea-trays, cups, saucers, baskets, album covers, etc., not even excepting those of the Dutch and English imitation, compare with the manifold productions of the *Vieux Laque*, or even with the modern works of this branch of Oriental industry, which still are far behind their old models. In presence of that wonderful smoothness and finish which we feel to be so charming whenever we take one of these objects in our hands, of that lightness of material, and that unsurpassed accuracy of workmanship, that polish, and the variety and delicacy of the different tints and shades of the gold lacquer—in presence of all these charms, we forget the extraordinary forms,

and the quaint methods of decoration which frequently looks out for the most inappropriate and generally the most eccentric position for the chief ornament.

We might also discover in other branches of industry of those countries, many other excellences of which we might avail ourselves, if we would only overlook the oddness of their appearance and keep before our eyes what they have really good and worthy of recognition. Among other things there are their woven stuffs, from which many a happy motive may be gained, as from their paper hangings and their mural paintings, though these are of the most astonishing kind, for the Chinese artists are generally the more eccentric in design, the more highly they aspire, which is not the case with the Japanese. And lastly, and with especial emphasis, we would call attention to their embroidery, which, excellent in color, of just and masterly execution, is among the very best of modern productions of this natue. We think we have now said enough in this cursory notice, the object of which was to point out a new source from whence might be derived new motives, and what is so much needed, the renovation of modern taste and modern Art-Industy. The source flows indeed freely, but it must be wisely and carefully used.

ON AN AUTOMATIC DISCHARGE GAUGE.*

By THOMAS STEVENSON, F.R.S.E., M.I.C.E.

From "Engineering."

Next in importance to a knowledge of the rainfall of any district of country is the determination of the constant for absorption and evaporation. While the actual amount of rainfall is doubtless of value in meteorology, it is the available rainfall, or that which passes off the land, which is required to be known in all cases of water supply; and it has also an important bearing on the subject of agriculture. This quantity varies with different localities, depending on the geological formation, the nature of the vegetation, and steepness of the slopes of the hills and mountains.

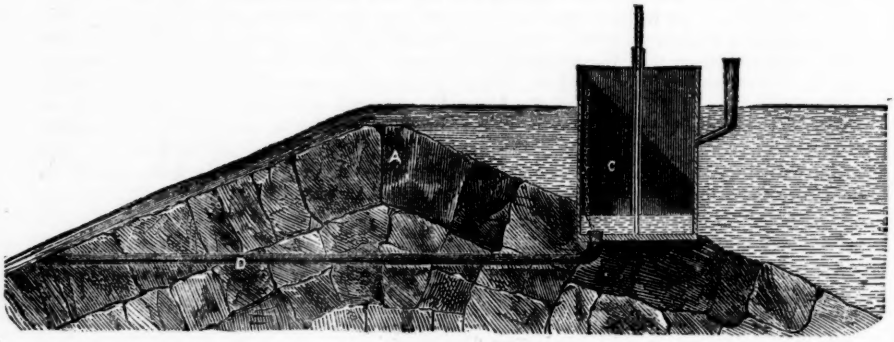
If a reservoir were of sufficient capacity to store up the whole of the available annual rainfall due to a given catchment area, we should then be able to obtain the required constant with perfect accuracy. This, however, probably exists nowhere, for in all reservoirs for the supply of towns a large quantity of water passes off by the waste weir or edgeboard, which is placed near the top of the embankment. The usual mode of ascertaining the quantity thus going to waste is by measuring once or twice a day during floods the level of the water above the top of the edgeboard, from which, by means of well-known formulæ, the quantity passing off is easily computed. It must be obvious that from such limited observations the quantity going to waste can only be very approximately ascertained, for the level of the water in the reservoir during floods is liable to great fluctuation.

Self-registering apparatus for indicating the variations in level, with the periods corresponding to such variations, might be formed by a float connected with a marker acting on a cylinder moved by clock-work. Another, and probably a simpler apparatus, was referred to by me at the last meeting of the Scottish Meteorological Society. Since then the details of the proposal have been drawn out and will now be described. A represents a cross section of a reservoir taken through the waste weir. B is a pipe perforated with small holes like a rose, the lowest hole in which is placed on the same level as the top of the edgeboard. A tube connects this with the tank C, which has a float with graduated rod, and from this tank a pipe, D, with waste valve, is led through the waste weir.

Whenever the water in the reservoir rises to the level of the top of the edgeboard it begins to flow into the tank through the lowest perforation, and as the water rises it will pass through more of these holes, and thus the water which flows into the tank will remain a constant submultiple of what flows over the weir, and can be read by the sluice-keeper on the graduated rod. After the height of the float is read off, the tank is emptied by

*Paper read before Section G of the British Association.

opening the waste valve, when the water will escape over the down-stream side of the embankment, and the float will sink to zero on the graduated stem. The values of the readings on the graduated stem must be found experimentally before the instrument is used, by the immersion in water of the perforated tube at different levels, so as to ascertain the quantity passing through the holes at different levels of immersion. In order to prevent dust from choking up the small orifices,



a protecting tube should be placed over the rose tube. In a properly constructed reservoir the length of the waste weir should be so designed as never to have a greater height of water than 1 ft. or 18 in passing over it in heavy floods, so that the perforated tube need not be longer than about 18 in. The capacity of the tank must be proportioned to the size of the perforations in the tube (which should be arranged spirally) and the number of hours when the sluice-keeper is absent, which at the maximum will probably be from 9 P. M. to 6 or 7 A. M., which would require about 9 or 10 hours' storage.

ON THE DELIVERY OF WATER UNDER GREAT PRESSURES.

By AMOS BOWMAN.

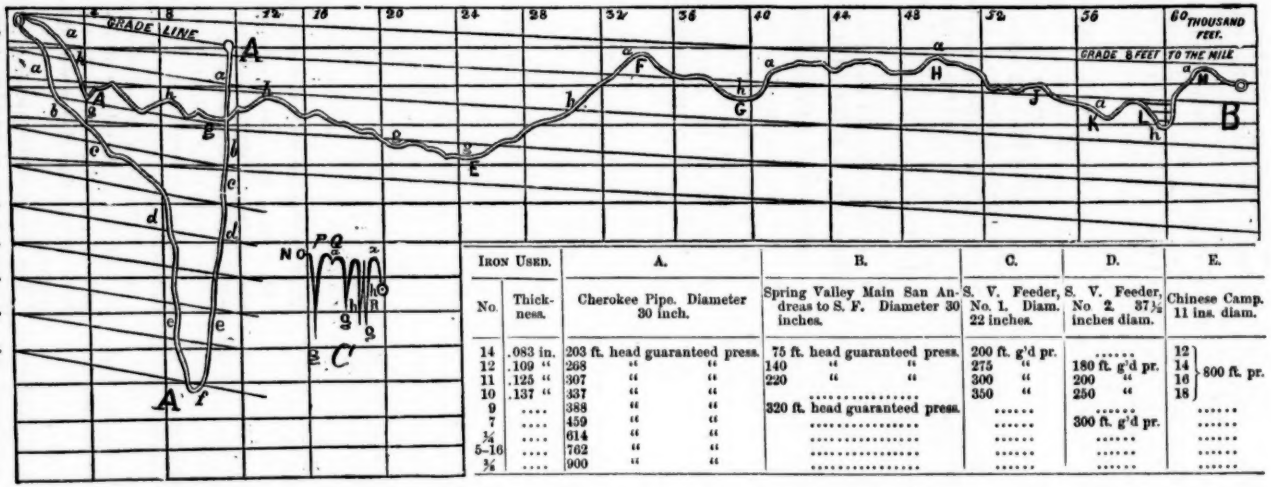
To set forth what has been done in a few well-known instances in California, in connection with suggestions originating in hydraulic mining, will be the most appropriate means of supporting our claim for having contributed valuable additions to the science of practical hydraulics. The necessity for carrying water over or through the greatest obstacles—over mountains and across sheer gulches of 900 to 1200 feet in depth, up again on the opposite side, and so to the locality where the water is needed, was the engineer's incitement; the object, gold, for the world's most urgent cry and demand; the results being a solution in the following facts, which are contributed for the use of engineers and practical men.

THE CASES A, B, C, D, AND E.

I select from sections furnished by Mr. Moore, of the Risdon Iron Works, under whose hand and judgment the leading works of this sort, in the State, have been executed, three leading ones, viz., the great Cherokee hydraulic mining pipe in Butte County, the Spring Valley main pipe from the San Mateo mountains to San Francisco, and one Spring Valley feeder; to which is appended a tabular statement of the dimensions of these and other pipes in actual present use, with facts touching durability, etc.

The Cherokee pipe is over two miles long, and has over 900 feet head and pressure; the Spring Valley is 14½ miles long, and has in several places over 350 ft., and in one 350 ft., pressure; and the pipe at Chinese Camp (not represented in the following) is 9,000 ft. or 1¾ miles long, and has 800 ft. pressure.

The thickness of iron gives a basis for computing the comparative cost of cast iron and of wrought iron pipe; ⅜ wrought



Iron Used.		A.	B.	C.	D.	E.
No.	Thickness.	Cherokee Pipe. Diameter 30 inch.	Spring Valley Main San Andreas to S. F. Diameter 30 inches.	S. V. Feeder, No. 1. Diam. 22 inches.	S. V. Feeder, No. 2. 37½ inches diam.	Chinese Camp. 11 ins. diam.
14	.083 in.	203 ft. head guaranteed press.	75 ft. head guaranteed press.	200 ft. g'd pr.	.....	12
12	.109 "	268 " "	140 " "	275 "	180 ft. g'd pr.	14 } 800 ft. pr.
11	.125 "	307 " "	220 " "	300 "	200 "	16
10	.137 "	337 " "	.....	350 "	250 "	18
9	....	388 " "	320 ft. head guaranteed press.	.....	.....	.....
7	....	459 " "	.....	.....	300 ft. g'd pr.	.....
¼	....	614 " "	.....	.....	.....	.....
5-16	....	762 " "	.....	.....	.....	.....
⅜	....	900 " "	.....	.....	.....	.....

Sections of Wrought Iron Mining and Supply Pipe.—*Location of Pipes.*—A. Cherokee Hydraulic Mining Pipe; capacity 1,900 Miners' inches, or 50 cubic feet per second. B. Spring Valley Main, San Andreas to S. F.; capacity 700,000 gallons per day. C. Spring Valley Feeder, No. 1; capacity 7,000,000 gallons per day. D. Spring Valley Feeder, No. 2. E. Chinese Camp.

Character of Iron Used at Various Heads.—*a.* No. 14 Iron. *b.* No. 12 Iron. *c.* No. 10 Iron. *d.* No. ¼ Iron. *e.* No. $\frac{5}{16}$ Iron. *f.* No. ⅜ Iron. *g.* No. 9 Iron. *h.* No. 11 Iron.

Localities in Detail.—A. Caguchin Rancho. C. Road, Tanforan. D. 12-Mile School-house. E. 12-Mile Depot. F. Abbey Homestead. G. School-house Gulch. H. San Miguel. J. San Jose Railroad Crossing. K. Industrial School. L. Old Flume. M. Outlet at San Francisco. N. Inlet Spring Valley Feeder, No. 1 (C). P. San Andreas Valley. Q. 17-Mile House. R. Outlet near McMahon School-house.

iron sustaining a pressure of 385 lbs. to the sq. in., for which 3 in. cast iron (nearly) would be necessary for safety.

A carries 3,000 miners' inches with the head it has. The whole line of B is working perfectly, the limit run to being about half the pressure of the Cherokee pipe, arising from a necessity for a greater degree of safety.

The circumstances connected with the discovery of the practicability of such enormous heads in large conduit pipe, made of sheet iron, arose from the fact that in the engineers' formulas, and in practice everywhere, the tested safe pressure has always been accepted as the axiom; that is, the pressure a boiler would bear per sq. in., for example, without danger of explosion; but it was found necessary in connection with mining conditions, such as freightage in the mountains of California, to use thin, portable and cheap pipe; on which in using a higher and higher head was gradually used—since no great damage could result from bursting—until the limits became pretty well established amongst miners at a far higher figure than was ascribed to iron for other purposes.

Spring Valley being near San Francisco and in a populous county, the risks of damage from bursting would be far greater than in the mountains; it is for that reason that the Spring Valley pipe is made so much stronger, as seen in the table.

In proof of the utility of investments in pipe for mining, the Cherokee water used in one mine, is at the present time washing ont $1,000 of gold per day. Quite a number of other similar new enterprises could be mentioned in this connection, were the subject in place; that at Cherokee involving, *en passant*, also a tunel for outlet, which will require five years to run.

To make use of the above figure, the method would be: that if a 23-in. pipe, for example, stands so much, a 12 in. pipe, or any other required, ought to bear so much less, the rule being that where the diameter is the same, the thickness of iron is as the height; or, where the height is the same, the thickness is as the diameter.

EXAMPLES OF DURABILITY.

1. Smartsville pipe, 16 in. diameter to 18 iron, not painted inside, painted outside, 180 ft. pressure, laid 1861—10 years.

2. Smartsville, 40 in. diameter, 3-16ths iron, with $\frac{1}{4}$ alternately, 2,200 ft. long, coated outside, laid 1861—10 years.

3. San Juan, 36 in. diameter, No. 12 and 14 iron, coated inside and out; pressure 55 ft.; running 10 years—estimated at 20 years.

4. Chinese Camp, 11 in. diameter, delivering 300 miners' inches. Nos. 12, 14, 16, and 18 iron; 9,000 ft. long; 800 ft. pressure; laid in 1868—2 years.

5. Cherokee—6 months.

The fractional expressions designating pipe or sheet iron are fractions of an inch; the numbers, as "No. 9 iron," refer to the English Ironmongers' gauge, an arbitrary system of designation, in which No. 11 is, for example, about equal to $\frac{1}{8}$ in. in thickness. (See Molesworth.)

RIVETING AND MANUFACTURING.

The following table gives items of importance concerning the riveting of the seams, the diameter of the rivets for each size of iron, and the distances between them, for both the longitudinal and the round seams.

No. of Iron.	Diam. of Rivets.	Distance between the Rivets.		
		Long. Seam, double riveted.		Round Seams.
		Horizontal.	Vertical.	
14	½ inch.	1¼ inch.	⅝ inch.	⅞ in.
12	½	1¼	⅝	⅞
11	5-16	1⅜	⅝	1
10	⅜	1½	⅝	1⅛
9	⅜	1⅝	¾	1⅛
7	7-16	1⅞	1	1¼
½	½	2¼	1¼	1½
5-16	⅝	2⅝	1⅜	1⅞
⅜	¾	3¼	2	2¼

COMPARISONS OF WROUGHT AND CAST IRON.

Cast iron has some advantages over wrought iron. While weighing more, it will last from three to ten times as long, the iron being, for some unknown reason, less liable to oxidation. It is, when broken, worth one cent per lb., while wrought pipe iron is not worth cutting up in California. Anything above 16 or 18 in. would in all cases be better wrought; 24 to 30 in. of cast iron would be too expensive.

The city distributing pipes of the Spring Valley Co. are of cast iron; usually about

¾ in. in thickness, which is four or five times the quantity of iron that would be necessary if the same were wrought instead of cast.

A 2 horse team will walk along freely with 250 ft. of 18 in. wrought iron pipe; while 20 ft. more or less of cast iron would make a sufficient load for them.

IRON AND STEEL NOTES.

MACHINE PUDDLING.—Is the finished iron trade just within reach of that of which they have been so long in quest? It really seems like it; and yet the news appears too good to be true. The problem will, however, soon have its solution. We shall then know if in the United States there is at work a rotary puddling-furnace which, although not very different from that with which Mr. Menelaus has been experimenting, yet has distinguished itself with the important difference of having been a success, whilst the British machine cannot be so regarded. It will be some consolation for men who have nationality jealousies, that if all that is claimed for Mr. Danks's machine should prove true, then that Mr. Danks, if we are not misinformed, is not an American, but an Englishman. Our information is that Mr. Danks is a native of the Black Country, and that in early life he was actively engaged in iron manufacture about Dudley and West Bromwich. But whether this be so or not, and we mention it only that a yet closer interest may thereby be invoked in what he has done, Mr. Danks has deported himself in reference to his invention in the frankest possible manner. The paper that he contributed to the recent meeting of the Iron and Steel Istitute, and the explanation with which he accompanied it, all of which was reported in the Supplement to the Journal of September 2, will go far to make the meeting in Dudley more memorable in the history of the iron trade than that meeting in Cheltenham, at which Mr. Bessemer read to the British Association his famous paper, will prove to the steel trade. It was impossible to resist the conviction that Mr. Danks had been most straightforward. The report that we supplied at the time will have conveyed that impression to every reader. Much deeper will that impression have been made upon the minds of those who listened to Mr. Danks. Side by side with that of which most of us have knowledge, in reference to some inventions of American origin, and in respect of some American inventors, this is most encouraging at the present stage of the inquiry. To the uncertainty which too often overhangs the English mind on such matters, and to the good reason there often is for it, Mr. Menelaus bore testimony before Mr. Danks got up, when he remarked that without at all disputing that Mr. Danks had accomplished all to which he laid claim, he could not forget that some time ago an American inventor was at the Dowlais Works for about a year, receiving all the help that the firm could afford him, yet he was unable to make anything else than a miserable failure of that which it had been said was a splendid success in America. Whilst such experiences reasonably make the British iron master cautious, they do not prevent him from looking with hope, amounting almost to confidence, to the result of the inquires that he is about himself to institute into the merits of the new claimant for his favor.

Mr. Danks has not brought his invention under the notice of the iron trade of Great Britain before it has been well tested in the States. His paper furnishes particulars enough of the extent to which his machine has supplanted the old hand-puddling furnaces. But independent testimony comes direct from the States to conspicuous members of the industry here. Mr. Walter Williams, the honorable Secretary of the Iron masters' Association of South Staffordshire, has a considerable experience of the finished iron trade, not only from a life-long practical acquaintance with it at home, but from careful observation of what is being done as well throughout the States as in those portions of the continent of Europe that are open to the inspection and the visits of the English ironmaster. He has been seeking to solve the machine-puddling problem. About to examine and pronounce upon the drawings of such an apparatus that had been submitted to him, he has been arrested by a message from the New World, of which the following is the pith:—"Withold your judgment on the mechanical puddler; Danks, a man in Cincinnati, has got a complete success." Better than this, Mr. Hewitt, one of the most accomplished members of the American iron trade, bears testimony in its favor. He, too, declares it a success, and enforces the testimony by adopting the machine in the place of the old furnace at an establishment in which he is pecuniarily interested. Hardly any room is, therefore, left for doubt that there is full truth in the asseveration of Mr. Danks himself, to the effect that the machine is "as truly a success as that the members of the Iron and Steel Institute are men."

Assuming, then, that in America they have taken the one step that in England we have halted at, the inquiry arises—can that one step be taken here? That one step is an enduring lining. As to Danks's machine, and the machine which is the invention of Mr. B. P. Walker, of Wolverhampton, with which, as the purchaser of the patent rights Mr. Menelaus has been experimenting, we agree in great part with Mr. E. Wiliams. That gentleman remarked that looking at Mr. Danks's machine with the eye of a practical man, he did not see anything in which it was likely to differ from what could be effected with the Dowlais machine, with Mr. Menelaus at the end of it. But Mr. Williams could not see the initial lining, to which Mr. Danks's success is almost entirely owing, and at which, he asserts, after it has been once applied, you may "fire till doomsday without destroying it." It was the want of such a lining that defeated Mr. Menelaus. Mr. Danks finds in America a certain native mountain ore. Its value consists in this—that it contains a very small per cent. of silica. Any ore, Mr. Danks affirms, that contains no more than 5 per cent. of that ingredient will effect the purpose. Whilst it is for our own iron trade, we take it, and not for Mr. Danks, to find such a material, still that gentleman points out that he has seen in this country a Norwegian iron ore that contains even a smaller percentage of silica than 5 per cent., which seemed to him to be suitable for the purpose.

Upon being told that tap cinder contained only 2 per cent of silica, Mr. Danks expressed his belief that that would accomplish the purpose. He may be right with reference to the Norwegian ore, but we think he spoke without sufficient informa-

tion when he testified in favor of tap cinder. Our own experience of the bulk of tap cinder is that it contains a larger proportion of silica than is here indicated; and, next, we know that before Walker's machine passed into the hands of Mr. Menelaus tap cinder was tried for a lining and failed. But tap cinder and Norwegian ore, and any other material that suggests itself to them, the deputation of the Puddling Committee of the Iron and Steel Institute may take to America, and with it any and every kind of pig iron used in this country, and there, as we understand, with Mr. Danks himself to assist them, put lining ingredients and raw material to such a practical test as will enable them fully to report upon the merits or demerits of the machine in its application to the finished iron manufacture of the United Kingdom. It is hardly needful to say that the trade has confidence that the Committee will make their experiments in every way thoroughly, so that nothing shall remain to be decided by experiments on this side, inasmuch as to conduct thorough experiments in this country would involve a pecuniary outlay of no inconsiderable extent. In the interest of the great national industry affected, we look for further information from the Committee with much expectation.

Since the above was written the following has been made known: The Puddling Committee met last week, and decided to send out a Commission of three gentlemen. Mr. G. J. Smelus, of Dowlais, and Mr. J. A Jones, of Middlesborough, were requested to form two of the Commissioners, and the selection of a third gentleman was left to the South Staffordshire ironmasters. The Commissioners will take with them 10 tons each of Welsh, Cleveland, South Staffordshire, and Derbyshire pig iron, together with fettling available in this country. They are expected to sail in about 10 days, and will be accompanied by Mr. Danks himself. They will receive their instructions previous to starting, as the Puddling Committee have arranged to meet them at Liverpool the day before they sail. In case the Commissioners should send a favorable preliminary report, it is quite probable that arrangements will be made for putting up an experimental furnace and appliances in England for the purpose of thoroughly testing the plan. A number of firms have already expressed their willingness to find the needful funds, Mr. Danks making arrangements for allowing the cost off royalties that may accrue in England.—*Mining Journal.*

THE ACTION OF WATER ON IRON.—Mr. Sainte-Claire Deville subjected perfectly pure iron to the action of water vapor of known tension and temperature, at the same time maintaining the temperature of the iron constant throughout each experiment. The apparatus he employed was a porcelain tube, to contain the iron communicating at one end with a glass retort, which furnished the water-vapor, and at the other with a manometer. Arrangements were made to exhaust the apparatus by a Sprengel pump, or to pass through it hydrogen or other gases. Constant temperatures were obtained by the use of an oil or a mercury bath, or by the vapors of boiling mercury, sulphur, cadmium, or zinc, the respective temperatures of which are 360 deg., 440 deg., 860 deg., and 1040 deg. Cent. With the apparatus he found —1. That iron continues to oxidize in water-vapor, until at a fixed temperature the tension of the hydrogen set free becomes constant.—2. At the point of maximum tension for any given temperature, lessening the pressure by withdrawal of some of the hydrogen, causes a renewal of the action of the iron on the vapor, which continues till the constant is restored; or if hydrogen is sent into the apparatus, so that the pressure is increased beyond the constant value, some oxide of iron is reduced, and the pressure restored by the condensation of the water thus formed.—3. When heat is applied to the apparatus, the tension is preserved by the *condensation* of some of the hydrogen on the oxide of iron.—4. When the temperature of the vapor is maintained the same, but that of the iron is made to vary, the tension of the hydrogen is less as the temperature of the iron increases. At 200 deg. Cent. the tension of the moist hydrogen = 100 mm.; at 260 deg. it is 68.8 mm.; at 360 deg., 45 mm.; at 440 deg., 30.4 mm.; at 860 deg, 17.7 mm; at 1040 deg., 13.5 mm.; and at the melting point of iron, 9.7 mm.—5. The higher the tension of the water-vapor, the temperature of the iron remaining the same, the higher is the tension of the hydrogen, and as the tension of the vapor increases, the increase of tension of the gas is more than proportionate, the difference of increase becoming less and less, however, as the temperature of the iron is raised.—6. All these laws hold good when a small quantity of hydrogen is allowed to act on a large quantity of oxide of iron. M. Sainte-Claire Deville also accounts for the singular erosion of the iron of steam-boilers by distilled water, by the fact that iron is slowly attacked by steam at 150 deg. Cent. The oxide formed by steam acting on iron at the temperature of 440 deg. Cent. has a composition corresponding to $Fe^4 O^5$; it is amorphous, black, magnetic, is scarcely affected by nitric or sulphuric acids, but is readily soluble in cold hydrochloric acid, forming a deep brown solution, with which potash forms a black precipitate. The remarkable fact is thus clearly elicited, that iron is much more acted on at low temperatures than at high ones.—*Mining Journal.*

RAILWAY IRON IN BRITISH AMERICA.—The great demand for railway iron which has been provoked by the revival of railway enterprise in British America still continues apparently unchecked. This will be seen by an examination of the exports of railway iron from the United Kingdom month by month this year in the direction indicated:

Month.	1869.	1870.	1871.
January.....Tons	110	—	100
February	1,113	750	—
March	2,224	2,583	2,607
April	4,756	5,371	5,929
May	4,789	3,450	6,077
June	4,618	3,495	12,566
July	1,648	6,763	9,859
August	3,356	2,589	10,976
Total	22,614	25,001	48,114

This increase in the demand in a long stagnant quarter has been one of the most encouraging features this year in the iron trade. It has compensated, in some degree, for the decline in the consumption of railway iron in India, and it is also valuable, inasmuch as it augurs a still larger demand in the future. At present, the work of railway construction is being hurried on in Canada, the principal new lines on hand being the Intercolonial, the air-line of the Great Western Railway

of Canada; the Canada Southern; the Wellington, Grey, and Bruce; the Toronto, Grey, and Bruce; the Toronto and Lake Nipising; the Toronto, Simcoe, and Muskoka Junction; the North Grey; the Canada Central, etc. Of these lines the most important is beyond all doubt the Intercolonial Railway, and although this line has reached at present only an imperfect stage of development, it has made sufficient progress to justify the anticipation that it will be distinguished by a high degree of stability and excellence. The rails are of the best English steel, weighing 64 lbs. to the yard, and they are suited to resist the heaviest traffic, and to admit of the highest speed. All the bridges, with 3 exceptions, will be constructed of iron; these 3 were too far advanced before the arguments of Mr. Fleming, the chief engineer, prevailed; but there will be no difficulty in replacing the wooden bridges at Rivière du Loup and two other smaller ones with iron, as the piers throughout are of solid masonry. A great quantity of steel rails and rolling stock have been accumulated for the Intercolonial system, which will be in working order by the close of 1872 or the commencement of 1873. The line will be steel-railed throughout, and this policy on the part of the Commissioners who have been intrusted with the great work, marks an epoch in the railway history of Canada. Hitherto Canadian railway enterprise has been crippled by the enormous cost of renewals and maintenance, but the Intercolonial Railway Commissioners have profited by experience, and have resolved to get rid of this difficulty altogether by laying steel rails at the outset. The example will, no doubt, be followed with all practicable speed by the other chief Canadian railways—certainly by the Grand Trunk and the Great Western of Canada. The Grand Trunk once steel-railed, and the cost of maintenance once brought down to a reasonable level, the position of its long-suffering share and bond holders will be greatly changed, and they will enjoy at last a fair return upon their capital. If this result could be attained, we believe it would prove highly beneficial to Canada generally, as every disappointed Grand Trunk investor has naturally become a severe critic of everything Canadian. With an improvement in Canadian railway credit, there would be an improvement in Canadian affairs generally, and although anything like precipitation in railway construction is to be deprecated, as well in Canada as in other parts of the world, the regeneration of the Grand Trunk would, doubtless, give a still further impetus to Canadian railway enterprise. The reduction in the cost of steel rails and the severity of the Canadian winters render certain a large Canadian demand for the new essential element in a thoroughly sound permanent way. Further, we may expect that the Canadian demand for railway iron—a phrase which must, of course, be taken to include steel rails—will be augmented, from the fact that Canada is only now becoming a great power in the world. So long as the mother country cared little about her colonies, but was engrossed with her great struggle against Napoleon Bonaparte, so long as Canada was disunited and torn by intestine convulsions, so long as Canada remained poor and English capitalists remained short-sighted, so long Canada languished on without much effort to turn her great natural resources to account. But all this is changed. The Canada of to-day is being riddled with railways, whilst she is mapping out more; she has united her scattered provinces, and with the strong arms and stout hearts which she is now seeking on this side of the Atlantic, she bids fair to expand into one of the first nations of the earth.

A new puddling and heating furnace, invented by a Mr. Howatson, is exciting considerable attention at the Dudley Iron Works, England, where it is being introduced. The specialty of the furnace consists in supplying hot instead of cold air to the grates of the puddling and heating furnaces, and it is said that in one year coal and iron to the value of £187 may be saved in a puddling furnace, and over £450 in a 12-inch mill heating furnace, by its use. The ash pit of the furnace is closed by a door, and the opening of the grate is also closed in the same manner, the air required for the combustion of the fuel being obtained through flues below the chimney stack passing underneath the heating chamber. The waste heat from the furnace is made to heat the base of the stack, and this, together with the heat from the furnace, raises the temperature of the air for combustion to a high point. It was mentioned that this patent heating furnace has been tried at the Earl of Dudley's Round Oak Ironworks, under the superintendence of the manager, Mr. R. S. Casson. In one week of ten turns, when a 12-in. mill furnace had got into regular working order, the exact result was as follows: A saving of 5 tons 18 cwt. 0 qrs. 17 lbs. of coal, 1 ton 2 cwt. 1 qr. 3 lbs. of iron, and a loss of 2 tons 8 cwt. 2 qrs. 3 lbs. of cinder, the decrease in the latter amount being accounted for by the saving in the iron. The furnace has worked better, the iron being sooner and more uniformly heated, the labor of the furnace-men is diminished, as less firing is required, and there is every appearance that the brick lining will last much longer than is usual with the ordinary apparatus. A puddling furnace has recently been tested at Mr. Thomas Vaughan's, Bishop Auckland Iron Works, and there was a saving during the first week it was in operation of 4 cwt. 0 qrs. 9 lbs. of coal, and 2 qrs. 0 lbs. of iron per ton of puddled bar made. The results now are still more favorable, and the saving of coal is over 5 cwt. per ton. Neither of the furnaces above mentioned were furnished with the arrangement for consuming smoke, or no doubt a much greater saving would have been accomplished. There was not a melting chamber attached to Mr. Vaughan's furnace, because of the prejudice of the men, which it was thought would lead them to tamper with the appliances. At some future trial it is intended to complete the apparatus. The inventor accounts for the great saving as follows: By heating the atmospheric air from the furnace itself, a saving would be effected of something like 25 per cent. over the old method, for it is natural to suppose that the cold air is robbing the furnace of so much necessary heat, which must be again supplied at the expense of extra fuel. There can scarcely be any doubt that the quantity of heat taken up is waste heat, but that would not account for the whole of the saving, were the total amount of heat taken in by the air got at no expense of fuel. He considered the reason lies in the superiority of hot over cold air for the consumption of fuel; the advantages of which are to be noticed in the application of the former to the blast furnace.

The only effect the heat has upon air is to ex-

pand it, and when this is done there is a much less weight of oxygen for a given volume, than in cold air; and the latter, therefore, containing the largest amount of the supporter of combustion, might be taken to compensate for the sensible heat of the rarefied air. Oxygen, when heated, combines more readily with the incandescent carbon in the grate of the puddling furnace, and this is, perhaps, because it enters the fire at nearly the temperature required for combustion, so that it does not rob the already burning fuel of the heat necessary to raise it to this degree. In the ordinary furnace, when cold air is supplied immediately under the bars of the grate, it expands on entering the fire, and takes up a quantity of available heat to raise it to the temperature it finds in the furnace. In the improved furnace, however, a much smaller grate answers the purpose, and this leads to a still further saving; for in the ordinary apparatus, with so large a grate, and fired as it is from a small door in the side, it is almost impossible to distribute the fuel fairly over the whole surface, and at times there will be places where the layer of fuel is thin, and others where it is not covered at all. Through these places, large quantities of cold air are drawn, which, mixing with the other gases, has a tendency to cool the furnace. This causes waste of the iron by oxidation. In the patent furnace, there is less grate area, and less opportunity for the passage of air, and that coming under is readily consumed. The result is a small loss of iron and a great saving of fuel. The melting chamber also saves both time and fuel. There is also an apparatus for consuming smoke connected with the invention, which leads to a still greater saving of fuel.

RAILWAY NOTES.

THE RAILWAY OVER MONT CENIS.—The following extract from Mr. Whymper's "Scrambles Amongst the Alps" may be interesting to our readers as a popular account of the Fell Railway as viewed by unprofessional eyes:—The railway itself is a marvel. For 10¾ miles it has steeper gradients than one in 15. In some places it is 1 in 12½! An incline at this angle, starting from the base of the Nelson Column in Trafalgar square, would reach the top of St. Paul's Cathedral if it were placed at Temple Bar! A straight piece of railway constructed on such a gradient seems to go up a steep hill. 1 in 80, or even 1 in a 100, produces a very sensible diminution in the pace of a light train drawn by an ordinary locomotive; how, then, is a train to be taken up an incline that is 6 times as steep? It is accomplished by means of a third rail placed midway between the two ordinary ones, and elevated above them. The engines are provided with two pairs of horizontal driving-wheels as well as with the ordinary coupled vertical ones, and the power of the machine is thus enormously increased; the horizontal wheels gripping the centre rail with great tenacity by being brought together, and being almost incapable of slipping, like the ordinary wheels when on even a moderate gradient. The third rail is the ordinary double-headed rail, and is laid horizontally; it is bolted down to wrought iron chairs 3 ft. apart, which are fixed by common coach-screws to a longitudinal sleeper, laid upon the usual transverse ones; the sleepers are attached to each other by fang-bolts. The run across the top of the pass from the Summit station to the Grande Croix station—a distance of about five miles—is soon accomplished, and then the tremendous descent to Susa is commenced. This, as seen from the engine, is little less than terrific. A large part of this section is covered in, and the curves succeed one another in a manner unknown on any other line. From the outside the line looks more like a monstrous serpent than a railway. Inside one can see but a few yards ahead, the curves are so sharp, and the rails are nearly invisible. The engine vibrates, oscillates, and bounds; it is a matter of difficulty to hold on. Then, on emerging into the open air, one looks down some 3,000 ft. or 4,000 ft. of precipice and steep mountain side. The next moment the engine turns suddenly to the left, and driver and stoker have to grip firmly to avoid being left behind: the next, it turns as suddenly to the right; the next there is an accession or diminution of speed, from a change in the gradient. An ordinary engine, moving at 50 miles an hour, with a train behind it, is not usually very steady, but its motion is a trifle compared with that of a Fell engine when running down hill. It may be supposed from this that travelling over the Fell railway is disagreable rather than pleasant. It is not so; the train is steady enough, and the carriages have remarkably little motion. Outside they resemble the cars on the Swiss and American lines; they are entered at the end, and the seats are arranged omibus-fashion, down the length of the carriage. Each carriage has a guard and two brakes—an ordinary one, and a centre rail brake; the handles by which they are worked come close together on the platform at one end of the carriage, and are easily worked by one man. The steadiness of the train is chiefly due to these centre rail brakes. They greatly diminish the up-and-down motion, and render oscillation almost impossible. The steadiness of the train is still further maintained by pairs of flanged guide-wheels under each of the carriages, which, on a staight piece of line, barely touch the centre rail, but press upon it directly there is the least deviation towards either side. There is no occasion to use the other brakes when the centre rail brakes are on; the wheels of the carriages are not stopped, but revolve freely, and consequently do not suffer the deterioration which would otherwise result. The steam is shut off and the brakes are applied a very few minutes after beginning the descent to Susa. The train might then run down for the entire distance by its own weight. In practice it is difficult to apply the proper amount of retardation; the brakes have frequently to be whistled off, and sometimes it is necessary to steam down against them. Theoretically, this ought not of course to occur; it only happens occasionally, and ordinarily the train goes down with the steam shut off, and with the centre rail brakes screwed up moderately. When an average train—that is, 2 or 3 carriages and a luggage van—is running down at the maximum speed allowed (15 miles an hour), the brakes can pull it up dead within 70 yards. The pace is properly kept down to a low point in descending, and doing so, combined with the knowledge that the brake power can easily lessen it, will tend to make the public look favorably on what might otherwise be considered a dangerous innovation. The engines also are provided with the centre rail brake, on a pattern somewhat different from those on the carriages, and the flat

sides which press against the rails are renewed every journey. It is highly desirable that they should be, for a single run from Lanslebourg to Susa grinds a groove into about ¾ of an in. in depth. Driving the trains over the summit section requires the most constant attention and no small amount of nerve, and the drivers, who are all English, have well earned their money at the end of their run. Their opinion of the line was concisely and forcibly expressed to me by one of them in last August: "Yes, mister, they told us as how the line was very steep, but they didn't say that the engine would be on one curve, when the fourgon was on another, and the carriages was on a third. Them gradients, too, mister, they says they are 1 in 12, but I think they are 1 in 10, at the least, and they didn't say how we was to come down them in that snakewise fashion. It's worse than the G. I. P., mister; there a fellow could jump off; but here, in them covered ways, there ain't no place to jump to."—*Engineer.*

American Street Cars Abroad.—During the past 3 or 4 years the builders of street cars in this and neighboring cities have enjoyed a large and profitable business in filling orders from all parts of the world, and the demands from foreign countries are steadily increasing. Cars built in this city are now in use in Belgium, Denmark, London, Liverpool, Glasgow, Birkenhead, and many other of the principal cities of the United Kingdom, Australia, etc., and recently proposals have been invited from a Russian company for cars to be run in the streets of Moscow. But our market for street cars is not limitted to Europe. Within the past year or two several horse railroads in Brazil have been supplied with cars built in New York factories. Other South American countries have also adopted the horse railroad system, and one large establishment in this city has furnished the cars for 6 lines in Buenos Ayres, 4 in Rio Janeiro, 2 in Bolivia, and 4 in Para and Pernambuco. Orders have also been filled for Chili and Peru, and others are in hand for San Paulo. None, we believe, have yet been sent to Lima; but the question of building horse railroads has been under consideration in that and neighboring cities for some time past, and the results accomplished by them elsewhere will, doubtless, soon decide the debated point in favor of a trial of the system An extensive trade has sprung up lately with the countries named in rails, machinery, tools, and other necessary materials in railroad construction and operations. This trade, which has been built up in spite of British competition, promises a steady and rapid development, the excellence of the articles of this class exported assuring us a permanent hold upon the markets to which they have already found admission, and opening the way for their more ready introduction into others where no demand for them now exists.

Cast Iron Railroads.—A novel use for cast iron has been introduced in Scotland, which is the adoption of the metal for railroads and tramways, at least thus far to a limited extent. At a meeting of the trustees of the Clyde Navigation Company, of Glasgow, the engineer reported that a cast-iron tramway which had been laid down on the South Quay for trial, had stood in a most satisfactory manner the most severe tests for more than 4 months. During this period the passing of railway and cart traffic had been almost continuous, but the tramway showed no signs, either displacement in line or level, or of any wear or need of repair in any way, being, to all intents and purposes, as perfect as when first laid down. Under the circumstances of the severe tests to which the tramway had been submitted, the results were considered highly satisfactory, and the further use of this style of roadway was recommended. Cast iron tramways are, therefore, to be laid upon all the quays and yards of the Navigation Company in Glasgow, with a prospect of good results and great economy. Here is an opportunity for American inventors in the street railway line.—*Iron Age.*

Northern Pacific Surveys.—The Kalama (W. Ter.) "Beacon" says: "A full party under Capt. J. R. Maxwell is at the Snoqualmie Pass, running a line down the Yakima, east, extending that surveyed last summer west from the Pass toward Puget Sound. Another party, under Hubert C. Ward, Assistant Engineer, has just finished locating the next 40 miles north of the 25 under construction; which 40 miles is upon the portage between the Lower Columbia and Puget Sound, and brings the western line within 17 miles of the waters of the 'Sound.'

"A party under Mr. Eastwick, Assistant Engineer, is also making a full survey up the Clearwater by the south fork, over the Bitterroot Mountain into Montana. A Barometrical party, under Mr. Chas. A White, Assistant Engineer, is to proceed to the Pend d'Oreille Lake, and explore the country toward the Passes of the Cascades, southwesterly.

"The Northern Pacific have wisely determined to make no mistakes in location for want of complete and exhaustive explorations and surveys. Camps are being built, and parties are organizing to commence grubbing and clearing upon the 40 miles located, which work is to be kept out of the way of a large grading force to commence on the grade early next season.

"Construction parties are upon the 25 miles under Resident Engineer F. Hinckley, which is being pushed with a *vim* to its completion by November 1st. The iron for the 25 miles is at Kalama, the ties are being distributed, and 2 locomotives are *en route* from San Francisco. The bridges are being rapidly constructed.

Underground Railroading.—In the construction of the Underground Railway in London, a part of the route extended under the Church of St. Nicholas, and to support the building while the the excavations were going on, the following plan was adopted: At intervals in front of the walls of the church, wells of the diameter of 3½ ft. were sunk to the depths of 40 ft., and these wells were then filled in with brick-work and cement. The same method was adopted to support a tall chimney stack in the neighborhood, and in both cases the old and new structures remained firm. Cuttings in another portion of the line were made through a mass of human bones 16 ft. thick, which were the remains of an old and disused burial ground. In the construction of the station at Cannon street, 2,000 workmen were employed, for nearly 4 months, within a space of 280 sq. yards, and 150,000 tons of earth and rubbish were removed, while 50,000 tons of new material were brought upon the ground.—*Chicago Railway Review.*

DENVER & RIO GRANDE NARROW GAUGE.—The Denver "Tribune" (16th) says that on the 15th the track-layers reached the 33d mile post, 2 miles beyond Citidal (or Castle Rock) station; 10 more cars of iron were received and forwarded to the front. Track iron is accumulating at St. Louis. Sidings have been put in at 3 stations. A very noticeable and probably gratifying thing to the officers of the road, is the traffic already enjoyed by the line. An average of 12 or 15 car-loads of lumber and wood are brought to Denver every day. The Company has a contract for delivering to this point 750,000 ft. of lumber for Kansas Pacific snow-sheds, to be built between Carson and Wallace. There are also 2,000 cords of wood awaiting shipment. The first stock shipment from one point was to have arrived the 15th, designed for exhibition at the fair, at Denver. Passenger cars leave daily, and are well filled—rather contrary to general expectations so early in the day of this road's operations. The telegraph line is being constructed. The poles are set to the end of the track, and the wire will be put up at once.

PAINSVILLE & YOUNGSTOWN (OHIO).—The "Iron World" says that New Yorkers are now building a 3-ft. gauge road from Painsville to Chardon, Warren, and Niles, on to Youngstown, Ohio, and that a company is organized to build a 3-ft. gauge from Leetonia to Hazleton, the greater portion being now graded and ready for the iron.

ENGINEERING STRUCTURES.

ENGINEERING WORK IN NEW YORK HARBOR.—For many years the removal of the obstructions to safe navigation at Hell Gate in the harbor of New York has been attempted with more or less success. From present appearances we should judge these attempts are finally to be crowned with success. Recently, General Humphreys, Engineer-in-Chief of the United States Army, accompanied by the Secretary of War, Generals Sherman, McDowell, Ingalls, Newton, and a host of other military men, visited the scene of the work, and inspected operations. Two years ago, Gen. Newton began the great work—that of removing rock obstructions between Hallet's Island and the land opposite, thus securing a safe, short, and important entrance to the harbor for vessels of large size. When Gen. Newton began this gigantic undertaking, he found that there were 3 acres of solid rock to be removed. Sinking a shaft to the water's edge, he marked out 10 immense cuttings, or alleyways, at equal distances of 15 ft. Some of these cuttings have been bored under the river from 50 to 140 ft. The excursion party descended into the shaft, and went far into one of the cuttings. The water dripped liberally through the roof of the alleys, sometimes in such quantities that suits of water-proof were necessary. The miners cut under the bed of the river, leaving huge pillars to support the roof above. In the alleys a line of rails is laid down, on which by cars the stone taken out is conveyed to the shaft and lifted to the surface. Despite the hardness of the quartz rock, the miners progress at the rate of 15 ft. per month. Air compressing machines are erected on the surface of the pit, and are connected with each of the 10 passages by pipes, at the end of which a machine will be attached to work a drill. This is the same arrangement adopted in boring the Mont Cenis tunnel. The distinguished military party were treated to a series of blasts, which quite astonished them, and gave them new ideas of the power of nitro-glycerine. Gen. Newton's plan for entirely removing the obstructions is as follows: When the entire distance has been excavated, and all the cross sections and pillars have been cut, or reduced to the smallest size, he proposes to blow up the 3 acres of rock all at once. Everything is to be filled with nitro-glycerine; all the apertures in which the exploding material is placed will be connected with electric wires; then the water will be let into all the passages and cover everything; the battery will explode the whole mass at the same moment, and all the rock will sink down into the alleys cut beneath, leaving a splendid passage for shipping of any tonnage.—*American Railway Times.*

THE SHA-WEI-SHAN LIGHTHOUSE, CHINA.—The island of Sha-wei-shan is situated at the mouth of the Yang-tsze river, opposite to the Tsung-ming, or north channel branch, in latitude N. 32 deg. 24¼ min., and longitude E. 122 deg. 14¼ min. All vessels trading between Shanghai and the northern ports of China have to pass this island, which lies right in their course, and there has been very generally felt the want of a light-house upon it. The Tsung-ming channel has long been used by native craft, and now a few of the light draught steamers occasionally use it. The channel generally used, however, is the southern one, and vessels bound north go round the Tung-sha light vessel before the course for Sha-wei-shan is steered.

In the beginning of last year designs and estimates were prepared by Mr. David M. Henderson, C.E., the chief lighthouse engineer, for this light-house, and shortly afterwards Mr. Robert Hart, the inspector-general of the Imperial Maritime Customs, sanctioned the prosecution of the works. The tower, lantern, and light were ordered in England by Captain Forbes, R.N., who at that time was marine commissioner, but has since resigned. In the autumn a few natives were sent to clear away the dense mass of trees entwined with creepers that were growing on the top of the island, and to cut pathways up two of its sides, which are exceedingly steep. The island is about 600 yards long, 300 yards broad, and 190 ft. high, with a narrow ridge on the top, that had to be cut down to afford space for the light-keepers' dwellings. On the 1st of January of the present year a European foreman landed with a number of natives, and put up the huts for the working party. A Henderson's steam-derrick crane, manufactured by the Messrs. D. Cameron & Co., of Glasgow, was erected on a cliff 50 ft. high, at the south-east corner of the island, rendering the landing of the heavy materials a simple operation, even in a heavy swell. The water for the building operations and working party was partly obtained by spreading out the corrugated iron, which was afterwards to be used for the roof, on a framework of bamboos, and the ridge pieces, when inverted, served as gutters to conduct the rain water into casks buried in the soil. On a few favorable places on the rocks narrow ridges of Portland cement guided the surface water into reservoirs of bricks, which were rendered water-tight by being backed with puddled clay, and plastered with ce-

ment. As a further precaution in case of there being little rain, a condenser extemporized out of gas pipe was attached to the boiler of the steam crane. On one occasion, when short of water, it was tried, and produced about 250 gallons of water in 9 working hours. The water for the light-keepers is stored in brick tanks, set and plastered with cement, of a total capacity of 2,400 gallons.

The island is very much exposed, being out of sight of the mainland, and in the event of a gale of wind the tender had to run for shelter inside of the Tung-sha light-vessel, which is 20 miles distant. The port of Shanghai, from whence all the building materials were procured, is 64 nautical miles distant. The light materials were landed in ordinary ships' boats, and a fish boat of about 5 tons capacity was ready to land the heavy cargo. The whole of the plates for the tower and base course of granite were stowed in a Chinese lorcha, which was towed to the island by the steam tender, and as a favorable opportunity occurred a temporary buoy was moored off the landing place, and the lorcha was hauled alongside the rocks under the steam crane, discharged, ballasted, and hauled off safely without the slightest damage. When the tower was erected, the whole of the light and lantern were taken in the Relief, a sailing tender, and landed at one time. In this case the wole afternoon of the 10th of May was expended in getting the tender under the crane, on account of the strong tide and swell that was on, and at 6 o'clock her crew wanted to haul out to sea for the night. The men had some food given to them, and at half-past 6 o'clock the first case was landed. By 11 P.M. the whole was safely landed, and the tender hauled off to the buoy. At 5 A.M. the following morning, a gale of wind was blowing, and a clear out had to be made.

The whole of the works were executed by natives, under Mr. Henderson's superintendence, with the assistance of an English foreman and mechanic. The light was first exhibited at sunset on the 1st of July. The optical apparatus is a catadioptric one of the first order, showing a fixed white light all round the horizon, and having its centre 229 ft. above high water, so that in clear weather it will be visible 22 nautical miles. The tower is painted black, and the light-keepers' dwellings are white. The house is built of brick, at a distance of 90 ft. from the tower, and has a passage running through its centre, with the keepers' rooms opening from it. These rooms are 16 ft. by 14 ft., and 10 ft. high in the clear. There is thorough ventilation under all the floors and over the ceilings. The roof is boarded with 1½ in. tongued and grooved Singapore red wood, felted, tarred, and covered in with corrugated galvanized iron, supplied by the Messrs. Morewood and Co., of Birmingham. The cast-iron tower was manufactured by the Messrs. Eastons, Amos, and Anderson, of London, whilst the light and lantern were by the Messrs. Chance. There was the usual difficulty in erecting the optical apparatus, as the putty used to secure the prisms in the gun-metal framing had swelled up and bulged all the lining plates to such an extent that the panels could not be got into their places. The lining plates were consequently removed, and the putty, which crumbled to pieces, was brushed out, and replaced by material procured in Shanghai. In ordinary weather the workmen on Sha-wei-shan could see the light of the Tung-sha light-vessel, although distant 20 nautical miles. This light is a catoptric one, by the Messrs. Wilkins & Co., of London.

The new light vessel for Niuchuang has arrived at Shanghai, after a very lenghthy passage from London, and on the 9th of July she proceeded north to her station at the mouth of the Liau river.—*The Engineer.*

PROPOSED TUNNEL UNDER THE CLYDE AT GLASGOW.—The enormous extent of the passenger traffic over the Clyde at Glasgow by the harbor ferries, together with the great danger attending the traffic, has led the Works Committee of the Clyde Trust to take action, with the view ultimately of constructing a passenger subway in lieu of the ferry at Clyde street, which is the one that is the most extensively used. Boring operations have been going on for some time at that ferry, with the sanction of the Works Committee. Three test shafts have been made, one on either side of the Clyde, and another within the quay wall. All of them will be put down to a depth of 85 ft., and all the results hitherto obtained are very satisfactory, showing that, so far as the soil is concerned, the construction of a tunnel would not only be practicable, but even easy of accomplishment. Estimates are now being prepared, in order to ascertain the cost of the undertaking, and the revenue likely to be derived therefrom. Several members of the Clyde Trust are quite in favor of the scheme, and there is every probability that before long it will assume a definite and practical shape.

In the month of December, 1864, a lamentable loss of life took place at the ferry already named, owing to the swamping of a ferry boat, which at that time was simply a two-oared boat, capable of carrying 24 passengers; but that number was exceeded on the occasion referred to, on account of a violent and headstrong rush of working-men who were returning home from work. Soon afterwards a small steam ferry-boat was put upon that station; but the fact of nearly 20 persons being drowned at the time naturally led many persons to think of proper preventive measures against such a loss of human life. Amongst the schemes devised there was one which was privately submitted to the harbor authorities by Mr. James Deas, C. E., who was then engineer to the Edinburgh and Glasgow Railway, and had no expectation that he would ever be in the position of engineer to the Clyde Trust, the post which he now occupies. It is the scheme devised by that gentleman which is now brought under the consideration of the Trust.

The following is an outline of the scheme which Mr. Deas submitted along with the plans which he sketched to accompany his letter: He proposed a malleable iron tunnel from 9 to 12 ft. wide by 9 ft. high, the top being 3 ft. or so below the present bottom; the approaches to the tunnel at the two ends to be by means of sloping brick archways or tunnels of a similar width and height. The latter he proposed to carry from the side of the two streets leading to the ferry, a few steps being made at the entrance so as quickly to obtain a sufficient headroom for the brick tunnels under the streets running parallel to the harbor. The entrances could be covered over in a manner similar to the coverings placed over the entrance stairs to the cabins of steamboats. Of course the tunnel would be properly ventilated, and lighted with gas, and a toll might be charged similar to that now exacted

at the ferries. It is believed that the additional safety of such a subway would induce many persons to avail themselves of its use who now never venture into the ferry-boat; and it is not likely that the revenue of the Trust would suffer in the slightest degree.

Such a tunnel would doubtless bring several other advantages. The quay frontage, at present occupied by the ferry stairs on either side of the harbor, would be made available for ordinary quayage purposes, and hence there would be additional revenue from this source. The amenity of the quays would be improved by having them, as at present, subdivided by the ferry stairs; and the traffic on the river would be much facilitated by having the ferry-boats dispensed with.

In the event of the scheme thus outlined, or any modification of it being adopted for execution, we shall take care to inform our readers from time to time of the progress made, and more especially of the means which may be had recourse to for the construction of the tunnel.

Plans for a similar work have also been prepared by Messrs. Story & Smith, Engineers, of West Regent street, Glasgow.—*Engineering.*

The Proposed Canal between the North Sea and the Baltic.—The Berlin correspondent of the "Standard" writes: "A great deal has lately been written about the proposed canal between the North Sea and the Baltic, and both the expense and the importance of the natural obstacles in the way of the realization of the project have been greatly exaggerated. The only elevation which would render a deep cutting or a lock necessary is from 2½ to 3½ German miles in breadth, and not more than 67½ ft. in height, and this can hardly be called a difficulty, as the soil is easily worked. The first estimate, 28,192,000 thalers, may have been too low, and it is known that the Prussian Minister of Commerce from the first contemplated the necessity of employing a much larger sum; but, all things considered, it is highly improbable that 6,000,000 more will be required. The breadth of the canal at the surface of the water is to be 226 ft. and at the bottom 76 ft.; its depth 31 ft. This would afford ample space for four vessels to pass each other, two of which might be large men-of-war. The length of the longest proposed line is 14 German miles, that of the shortest 11¾ German miles. The choice of the line to be adopted is the most difficult question that still remains unsettled, as every district in the Elbe Duchies wishes a share in the immediate benefits of the undertaking, and consequently exaggerates the obstacles in the way of other plans, and enhances the advantages of the project most favorable to itself. Besides this, it is desirable to unite, as far as possible, the interests of the merchant shipping with those of the navy. To meet the wishes of both parties it would be necessary to construct various branch canals, which would involve an additional outlay of from 10,000,000 to 15,000,000 thalers. The results of the experience gained in the late war render it almost certain that the port of Kiel will be chosen for the one end of the canal, the mouth of the Elbe for the other. It is highly probable that this and all other questions will now shortly be decided, and the work commenced."—*Building News.*

Poughkeepsie Suspension Bridge.—Eastern exchanges announce that plans have been submitted to the Poughkeepsie Bridge Co., which seem likely to be adopted, for a suspension bridge at that point, to be 130 ft. above the water, and 3,400 ft. in length, with two spans of 1,160 ft., and half spans of 650 each; the towers to be of masonry, and the foundations to be constructed 70 ft. below the surface of the water. The cables to be of steel or iron, and the carrying capacity ½ a ton to the lineal ft. The whole structure is to cost $2,600,000.

Council Bluffs Bridge.—The "Nonpareil" says that the columns of the Un. Pacific R. Co. bridge over the Missouri at Council Bluffs, are now all down to the rock foundation, and filled with concrete masonry to a point above high-water mark. On the west side of the river 2 piers are completed and ready for the superstructure. The first span, reaching from the stone abutment to the first pier on the west side, is nearly completed, and workmen commenced putting in the second span of the bridge last week. Six months ought to suffice to complete it ready for the passage of trains.

Hoosac Tunnel.—Progress for the month of August, 1871: East end heading 133 ft.; total 9,184 ft. from portal. Central shaft 31 ft. east; total 169 ft. east of shaft. West end heading 130 ft.; total 6,620 ft. from portal. Brick arch 27½ ft.; total 183½ ft. from portal.

The work of widening the Boston and Albany Railroad bridge at Springfield is nearly completed. —*Am. Railway Times.*

ORDNANCE AND NAVAL NOTES.

A British Naval Bull Dog.—The iron gunboat Scourge was floated out of No. 4 dock at Chatham Dockyard on Monday, August 26, to be taken down the river to have a trial of her machinery after the cleansing of her bottom. She was taken from Sheerness Harbor on Wednesday to the measured mile at the Maplin Sands, for a trial of her speed, when the mean of 6 runs at full boiler power was 8 545 knots. The Scourge is sister vessel to the Snake. They are gunboats of a peculiar class—small, but formidable—and might not inaptly be termed "the bull-dogs of the fleet." Each vessel is divided into 6 compartments, the foremost of which is allotted to the crew, the next being taken up by the gun and platform. The gun is the new pattern 18-ton, mounted on an iron carriage, which can be lowered into the vessel by a small engine—an operation which can be performed in the short space of 3 minutes, notwithstanding the great weight of the gun carriage and platform, nearly 27 tons. The engine for raising and lowering the gun is situated in No. 3 compartment, and works the capstan on the deck above. On each side of No. 3 compartment is a commodious cabin, on one side for the engineer, and on the other for the gunner. No. 4 compartment is taken up by the boilers and coal bunkers. In No. 5 compartment are the engines, which, although nominally of 28 horses, can be worked up to nearly nine times that power. The after, or No. 6 compartment, is appropriated to the chief officer. The vessel has only one small mast, for signal purposes. She will require a crew of about 18 officers and men, will be able to steam over 8½ knots per hour, can throw a pro-

jectile of 400 lbs. weight a distance of 3,000 yards, at which distance she is almost too small to be seen, and she will draw but little over 6 ft. of water when fully equipped. She has returned to Chatham to complete her fittings.—*Army and Navy Gazette.*

THE NAVY OF ENGLAND.—The navy of England is reduced to a state which would be ridiculous if it were not serious. We want at present two vice-admirals—one for the China command and the other for the Channel Squadron; and as it would be worse than useless to blind ourselves to the truth, we are bound to confess that we have no such officers at our disposal unless we re-employed the Hon. G. F. Hastings, or cause a survey to be made on the Hon. James Drummond. Here we are boasting that we are the first maritime power in the world, and we have not two spare vice-admirals. We have fortunately a goodly supply of rear-admirals, but if there is any truth in the rumors prevalent at the clubs, Mr. Goschen is about to commit a grave error. The officer who who is said to be nominated to succeed Sir Henry Kellett is "an excellent creature," but probably the last man on the whole list who should be sent out to occupy a post requiring not only intelligence, but decision and firmness on the part of the individual who may be called upon to fill it. The officer in question has many estimable qualities, but does he possess those which would constitute the able and dashing commander? Then, again, report is busy again with the name of another rear-admiral in connection with the command of the Channel Squadron. Not one word can be said against his fitness to succeed Vice-Admiral Wellesley, but his appointment would be regarded as a slur on the professional attainments of all the other officers of his rank who have not hitherto been employed, but we fear there is no other alternative. We are perfectly aware of the difficulties which Mr. Goschen has to contend with in distributing his patronage, but in the interests of the country and service we must speak out.—*Army and Navy Gazette.*

A NEW MITRAILLEUSE.—A new mitrailleuse was recently tried at the Camp of San Maurizio at Turin. This new weapon was proposed to the Minister of War, of Italy, by Capt. Mussini, of Florence. A commission of superior officers presided over the experiments. The piece was worked by Capt. Mussini, assisted by the engineer, and the Chief of the Works where the mitrailleuse was manufactured. The principle is like that of Montigny's system, but with great improvements which make it a very practical and effective arm; much is due to the great precision attained in the execution of all its parts, carried to a surprising degree of perfection; the deviation of all the parts of the mitrailleuse nowhere exceeds $\frac{2}{100}$ths of a millimetre, and $\frac{4}{100}$ths of a millimetre in the cartridges. This mitrailleuse has been constructed at the works of Mr. Sigl, of Vienna, the only engineer who has hitherto succeeded in distributing with such precision the openings, so as to fix, without any sensible deviation, the 37 barrels distributed equidistantly in one single circular pile. Each volley lasted 2 min., firing 635 times in each minute, viz., 10 3-5 shots per second.

The experiments were made at the following ranges, each occupying about 2 hours—viz., at 400, 700, 1,000, 1,500, and 1,600 paces; corresponding to 303.36, 530.88, 834.24, 1137.60, and 1213.44 metres. The results of each volley were graphically taken, and were obviously very destructive. The target was formed of a board 2½ centimetres thick, 3 metres high, and 30 wide, normal, and central to the line of firing; at intervals of 25 metres in rear of the first target there were placed others parallel to it, and arranged in such a manner as to represent a battalion formed in columns of companies; so that the shots which passed through or over the first target would strike the second, and so on successively. Of course the number of hits decreased from the first to the last target when the mitrailleuse was properly trained, but increased when the training was high. The proportion of effective hits is represented in the order of the distances we have given by the following numbers—95½, 79½, 65½, 31½, 27; which shows that even at the least favorable distance of 1,600 paces, 1213.44 metres or 1,327 yards, each of the 4 companies of a battalion formed in column would receive at least ¼ of the shots—that is, that not one ball is ineffective on columns of companies. Supposing that the 1,600 paces can be run in 8 min., at "the double;" that the mitrailleuse would fire more than 5,000 shots during that time; and that the battalion is composed of 600 men, each man, on an average, would have to run the gauntlet of 9 projectiles, and that, as we have said, upon the most favorable hypothesis.

The cartridges proved also to be very excellent manufacture, only 2½ per 1,000, *i. e.*, 1 in every 400, missed fire. There were no *contretemps* of any kind, and a member of the Commission expressed his opinion that humane considerations alone would dictate the rejection of this mitrailleuse on account of its terrible effects.—*Mechanics' Magazine.*

BRITISH IRON-CLADS BUILDING.—The following iron and armor-plated men-of-war are at the present time under construction for the Government in Her Majesty's Dockyards and by contract: The Fury, armor-plated turret ship, 4 guns, 5,030 tons and 1,000 H.P. engines, building at Pembroke; the Blonde, iron steam frigate cased with wood, 26 guns, 4,039 tons, 1,000 H.P. engines, building at Portsmouth; the Thunderer, armor-plated turret ship, of 4 guns, 4,406 tons, and 800 H.P. engines, building at Pembroke; the Rupert, iron-clad, ram, 4 guns, 3,159 tons, engines of 700 H.P., building at Chatham; the Gorgon, double screw, iron, armor-plated turret ship, 4 guns, 2,107 tons, and 250 H.P. engines, building at Jarrow-on-Tyne; the Raleigh, iron frigate sheathed with wood, 22 guns, 3,210 tons, and 800 H.P. engines, building at Chatham Dockyard; the Hecate and Hydra, double screw, iron, armor-plated turret ships, of 4 guns, 2,107 tons, and engines of 250 H.P. each, building at Poplar and Glasgow; the Frolic, Kestrel, Ready, and Rifleman double screw composite gun vessels, of 4 guns, 462 tons, and 100 H.P. engines each, building at Chatham.—*Nautical Gazette.*

THE HARVEY TORPEDO.—The crew of such ships as happened to be in the Yarmouth Roads recently, either under sail or at anchor, were considerably astonished by their vessels being made the subject of attack by a small steamer armed with one of Captain Harvey's sea torpedoes. The results were, of course, harmless, as the torpedo was not charged, although it was fitted with the

exploding apparatus. The object of the excursion was to test the capability of the crew of an ordinary merchant vessel to manœuvre the torpedo, and further to test the towing gear, and the certainty of action of the weapon when in use. A small paddle-wheel steamer, the Andrew Wodehouse, of the ordinary class, and of about 60 tons burthen, was engaged upon the occasion. The master and crew of the vessel worked the torpedo under the personal direction of Captain Harvey. The torpedo was one of a large number now being manufactured by the London Ordnance Works. It measured 3 ft. 8 in. in length, by 1 ft. 6. in. in depth, and 5 in. in breadth, weighing, when charged, about 1½cwt; on the present occasion, water was used to bring it to the service weight. The slings and buoy rope were of hemp, the towing rope being of ¼ in. diameter iron wire, controlled by a small iron brake, acting on the side of the drum on which the rope was coiled. As a temporary towing-yard, a spar was rigged across the quarter-davits of the steamer on the port side, a leading block being lashed on for the tow rope to reeve through.

Thus equipped, the Andrew Wodehouse started on her cruise, towing the torpedo well out from her side at an angle of 45 deg., with from 20 to 50 fathoms of tow line. The cutwater of the torpedo was at all times sufficiently visible to those on board the vessel to permit its steadiness and uprightness to be observed. The first attack was made against a brig coming on under full sail. The brig yawed, but the torpedo was successfully dipped under her keel with about 30 fathoms of line out. The second attack was against a brig at anchor, with 30 fathoms of tow line out. The torpedo was again successfully dipped under her bottom, both the firing levers being driven home, piercing the detonating capsule. Succeeding attacks were made with similar and invariable success upon other vessels both under sail and at anchor, the torpedo being well manœuvred, and always planted effectually against the object of attack. The final experiment was made with the steamer running at the highest possible speed, in order to test the strength and reliability of all the towing gear. It was also desired to know how much of the wire rope could be effectually veered out from the temporary towing spar, which was about 15 ft. above the water. The steamer attained a speed of 11 knots, and the torpedo was well out from her side at 45 deg, with 50 fathoms of tow line. Only a very few minutes were occupied in each attack, the time of striking being but a few seconds. The experiments were satisfactory, and went to show that if necessary our steam mercantile marine could, with little delay, and at a comparatively small cost, be transformed into a highly efficient offensive power. Although the enemy's guns, if ready, might be brought to bear on the torpedo craft, the latter has chances of escaping, as was proved by the experiments with the Camel tug against the Royal Sovereign, which took place at Spithead some months since.—*Engineering.*

Mode of Discharging Artillery.—Henry Bessemer, of homogeneous steel celebrity, is still "pegging away" at inventions some of which are in a quite different field from those that have brought him fame and fortune. Among the most recent of these is a novel method of discharging artillery. In this a vibrating pendulum is employed, which, falling from one support to the another, makes an electric contact with a fusee to fire the gun. In order to ascertain the distance of an object aimed at, an instrument is employed consisting of a telescope with an arm at right angles to its axis; in front of the lower half of the object-glass is a mirror inclined at an angle of 45 deg. to the axis; at the other end of the arm is another similar mirror, the inclination of which is adjustable and capable of accurate measurement. The instrument is directed at the object the distance of which is required, the upper part of which will then be seen directly and the lower part after two reflections. The movable mirror is then adjusted so that the two parts of the image of the object piece up accurately the one with the other. The scale in connection with the mirror will then indicate the distance in yards or other units.—*Am. Artisan.*

A German Naval Invention.—The "Bromberger Zeitung," in a letter from Dantzic, gives some particulars regarding a curious and interesting addition to the German fleet. Three boats are just now in course of construction in Devrient's dockyard, the destination of which is to place torpedoes under, and thus destroy an enemy's ships. These boats are built almost entirely of iron, and, being about 60 ft. long and only 6 or 7 ft. broad, they have nearly the form of a fish. The deck is not flat, but round, so as to be but little exposed to damage from an enemy's shot. While employed in active operations no one will be visible on board. Contrary to the usual system, these boats will be steered from the bows; and on the deck, above the rudder, there is a slight elevation to allow the steersman to stand on his feet, and a small opening about an inch wide to serve him as a look-out. As they are intended to operate close to an enemy's vessels the armor will be as thick as is consistent with high speed. The most curious part of the invention, perhaps, is that the tiny screw streamers, or barcassen (long boats), as they are called, use petroleum as fuel, which is contained in a number of iron receptacles in the stern, of sufficient thickness to be impervious to projectiles. The chimney is so small that it can scarcely in any case be hit. A narrow gallery, about a foot broad, and enclosed by an iron chain, runs round the boat. The machines have all been furnished by Stöckel and Wagenknecht, so that the boats have been produced in Dantzic from stem to stern. The hold for the torpedoes is in the middle of the boat, as well as the quarters of the crews. One of the barcassen has already been launched, and is only waiting for her engine. The two others are still on the stocks. A liliputian steamer has also been constructed in the same dockyard, in which the inspector of the harbor works will be able to go on his rounds with great rapidity. The whole thing is not larger than an average-sized rowing-boat; it has no deck, and in the middle is the miniature steam machine, which is no more than 2 ft. in diameter, and requires but little attention.

Breech-Loading Ordnance of the Middle Ages.—On Monday last a most interesting consignment arrived at the Royal Arsenal, Woolwich. It consisted of 3 bronze guns, manufactured evidently at an exceedingly early date, although in a most perfect state of preservation as regarded the various parts, and which were forwarded from Portsmouth by Admiral Milne, to whom they had been sent in transit from Rhodes

by Her Britannic Majesty's consul. We understand that a considerable amount of correspondence has taken place with reference to these and some other guns of a like nature, which were accidentally discovered by a diver at the bottom of the sea near Rhodes, and were at the time being sold for the sake of the metal which was contained in them, with a view of melting them down. Fortunately, however, this was arrested in time. These curious specimens of warlike constructive art are supposed to belong to a period anterior even to the date of the battle of Crecy, when guns are said to have been first used. But the great interest which attaches to them is contained in the fact that 2 of the number are breech-loading pieces of ordnance. These are about 5 ft. in length, and would contain a ball from 4 to 5 lbs. weight. At the breech end is a chamber, sufficiently wide and deep to contain a large vent-piece, which can be lifted in and out by means of a handle. This vent-piece is not solid as in the Armstrong gun, but has a space hollowed out within it evidently intended to hold the cartridge. Whether the ball formed part of the cartridge with the powder, or was rammed in afterwards at the muzzle, cannot be ascertained, but as the calibre of the barrel is greater than that of the chamber, it would appear that the latter surmise is correct. A plug passing through the breech of the gun, and through the solid end of the vent-piece, kept the latter in its place when the charge was fired, but there is an orifice in the cascable of each of the guns which may have contained a breech screw. But the material is so much eaten away that it would not be possible to determine whether there had been a thread upon the orifices or not. The vent-hole is at the side of the vent-piece handle, and so contrived as to be exactly upright when the plug is in its place. On the trunnion piece of one of the guns is the figure of a lion with wings. In a similar position on the other is a human figure apparently holding a book. But the carving is so nearly obliterated that it is difficult to distinguish whether these images are human or otherwise. Such was the breech-loader of probably the 14th or 15th century. Perhaps one of these days we shall be digging up the portable field telegraph which was used by Pharaoh in keeping up a communication with his base of operations when pursuing the Israelites! The third gun, which was received yesterday, is an ordinary-looking weapon, somewhat similar in shape to those which were used in the last century. It has a bore $3\frac{5}{8}$ in., measures about 9 ft. in length, and is also of bronze, but does not bear the same stamp of antiquity as the rest.—*Engineer.*

NEW BOOKS.

Hand-Book of British Fungi. By M. C. Cooke, M.A. London: Macmillan. For sale by Van Nostrand.

This long expected work, by one of our most industrious mycologists, has at last made its appearance. It contains descriptions of all known species of British Fungi, amounting to the enormour number of 2,809.

Each genus is illustrated by a carefully executed wood-cut. The student is aided in the discrimination of the genera *Agaricini*, by a series of colored tables.

The thanks of every lover of botanical science are due to the author for his valuable work, which, though of necessity a compilation, is not wanting in original matter.—*Quarterly Journal of Science.*

Elementary Treatise on Natural Philosophy. By A. Privat Deschanel. Translated by Professor J. D. Everett. Part II. For sale by Van Nostrand.

The second part of this beautiful treatise fully maintains the character exhibited by Part I., of which we gave an account some time ago. It is understood that the book is now half completed. The present part is occupied entirely with the consideration of Heat.

The present editor has added some valuable matter to the original edition.

When complete the work will be one of the most beautifully executed, as well as most satisfactory books on General Physics in the English language.

The Theory of Strains. By John H. Diedrichs, C. E. Baltimore: Smith & Trowe. For sale by Van Nostrand.

This is a complete compendium, for the calculation and construction of bridges, roofs, cranes, etc.

The methods employed in calculation are those of Ritter in his "Dach und Brucken Construction," with which our readers have been made somewhat familiar through the recent translated articles in our pages. Indeed both illustration and text will look familiar to those who have studied Ritter.

The different leading forms of trusses are discussed in logical order, and the method may be readily followed by young engineers not yet familiar with higher analysis.

Physical Geology. By Ralph Tate. London: Lockwood & Co. For sale by Van Nostrand.

This is a new addition to the well known Weale Series. It presents in a brief way, and good style, a discussion of the physical causes which have produced geological changes.

A separate treatise is to follow, devoted to Historical Geology.

The illustrations of the present work are numerous and good, and altogether the work presents the best brief compend of Geology that we have seen.

Manual of Mining Tools. By Wm. Morgans. London: Lockwood & Co. For sale by Van Nostrand.

Besides the necessary descriptions of the various tools, this little work also comprises observations on the materials from and processes by which they are manufactured; their special uses, applications, qualities, and efficiency.

A fine atlas, containing 235 wood engravings of mining tools drawn to scale, accompanies the text.

The introductory chapter is quite a complete treatise on steel, and the various processes by which it is produced.

The Workman's Manual of Engineering Drawing. By John Maxton. London: Lockwood & Co., Stationers' Hall Court, 1871.

This is a very useful little work for mechanics, or those who have yet to acquire the various "notions" necessary to mechanical drawing, and

it is consequently designed principally for the use of the "working engineer," who it is presumed has not had the advantage of instruction in the drawing office. Although the description of instruments and pencils there recommended, together with some of the minor operations respecting preparing the paper for drawing upon, are not such as we should prefer, it is evident that the treatise is written by a thoroughly practical man, and perhaps the very details to which we object might be of service to those who know no better. The instructions for setting out work, so far as they go, appear to be correct, but we could have wished to have seen in a work professing to instruct engineers a few more engineering examples for their imitation.

MATHEMATICAL INSTRUMENTS: their Construction, Adjustment, Testing, and Use. New edition, Vol. I. Drawing and Measuring Instruments. By J. F. HEATHER, M. A., late of R. M. A. London: Lockwood & Co. 1871. For sale by Van Nostrand.

This book was published in 1849, and since then has been used in Government Military and Naval Schools—forming also, by authority, part of a Midshipman's Kit

This tenth edition has been entirely rewritten for the purpose of describing the latest improvements; the subjects have also been separated into three portions, the second volume being devoted to Optical Instruments, and the third to those used in Surveying and Astronomical Observation. These changes are judiciously made; and we need say nothing concerning the well-known merits of so useful a book.—*Mechanics' Magazine.*

A RUDIMENTARY TREATISE ON ANALYTICAL GEOMETRY AND CONIC SECTIONS. By JAMES HANN. New edition, Rewritten and Enlarged. By J. R. YOUNG. London: Lockwood & Co. 1871. For sale by Van Nostrand.

In this work there is little except the general plan of the original left. Both in method and execution Professor Young's work is a decided improvement on Mr. Hann's, while it retains the important feature of cheapness, through which, in presenting sound mathematical works at an almost nominal price, the series of Mr Weale has done such good service to education.—*Mechanics' Magazine.*

MISCELLANEOUS.

AMERICAN VIEWS ON PATENT LAWS.—The Hon. Charles Mason, late Commissioner of Patents, has written George Haseltine, M.A., chairman of the meeting on the patent laws, reported by us last month, an instructive letter published at length by "Engineering," of which we give a brief abstract:—"I have," he says, "never had any serious doubt of the wisdom of a judicious system of patent laws. The public welfare is best promoted by inspiring individual effort in respect to invention, through the motive of private gain; and who can more justly claim the exclusive use of any property than he who has brought it into being? The American system of examination is productive of much advantage to inventors and the public, but I doubt the wisdom of lodging in officials an unlimited power of rejection. If the action of examiners were advisory and adjuvant, reserving to an applicant the ultimate right to a patent, at his own risk, the chief objection to this system would be removed. The fees by all means should be small—barely sufficient to defray the expenses of the Patent Office. Inventors are benefactors, and as a class are poorly compensated for their labor. The imposition of large fees discourages invention, and thereby checks the progress of civilization. This cannot be sound policy. Experience leads me to the conclusion that patents should be granted for more than 14 years; but this term, in most cases of merit, is extended by our office to 21, and often by Congress to 28 years. The new law limits the term of a patent to 17 years, which will, no doubt, hereafter be extended; and I do not think 21 years too long a period for the original grant. In one respect I like your system better than ours—your fees are paid in instalments, giving the patentee the option of keeping his patent alive. The French plan of annuities is carrying the matter rather too far. I think the English system better than the French or the American, and all that is needed is a reduced rate of fees. Experts are often very useful, but they are regarded with suspicion, and their opinions have little weight in our courts; therefore, what might be a great evil, carries in some measure its own remedy, and the interposition of jurors in patent suits is generally avoided by obtaining injunctions in Chancery, which is our usual remedy for infringements."—*The Globe.*

THE RAIN-FALL OF THE NORTH AND EAST OF ASIA.—M. Raulin, M. A. of Sciences, of Paris, proves by the table annexed that the summer rain-fall of the great plain of Central Europe extends beyond the chain of the Ural mountains, very far towards the East, as far as the shores of the Pacific Ocean, where the differences of relative quantities are even more striking. At Nijné-Taguilsk the minimum rain-fall in winter is but little more than $\frac{1}{4}$th of the maximum in summer; and at Nertchinsk is only about $\frac{1}{10}$th part:

	Quantity of Rain-fall.				
	Winter.	Spring.	Summer.	Autumn.	The Year.
Nijné Taguilsk.....	49	85	236	94	464
Tobolsk	61	58	230	102	450
Nertchinsk	9	59	268	126	462
Yaksutsk.....	47	87	85	91	260
Pekin.....	13	55	450	89	607
Macao.....	84	477	709	450	1720
Saigon.....	1	149	732	711	1593
Yokohama.....	75	191	806	386	1058
Manilla	123	121	866	641	1751

In China, at Manilla, and in Japan the same proportions are found, but at Macao there is a double maximum as yet unexplained (May and September).

COMBUSTION OF METALS by M. A. Ditte, M.A. of Sciences of Paris. The numbers obtained by the author explain different physical peculiarities of the metals examined. Thus, magnesium burns

with dazzling brilliancy, the combustion of zinc is energetic, that of Indium difficult, and Cadmium melts and oxidizes with a flame scarcely visible; heat and volatility decrease in the same order. Similar analogies are observed in the reduction of the oxides of the four metals, in the decomposition of steam, etc. The following table shows the striking parallelism of their different physical properties:—

	Magnesium.	Zinc.	Indium.	Cadmium.
Density.....	1.75	7.0	7.15	8.65
Equivalent.....	12	33	35.9	56
Specific heat..	0.2733	0.0955	0.088 theory	00.567
Point of fusion.	about 500°	about 400°	....	about 315°
Point of volatilization	" 1100°	1040°	red	860°
Heat of combustion	72,890	44,258	37,502	16,231
Color of the oxides	White	white, light yellow	deep yellow	orange or black.

MINING IN JAPAN.—While the arsenal at Yokoska and the mint at Osaka have been opened with the due amount of ostentation and publicity, the Japanese Government have recently had completed for them a more humble, but nevertheless quite as important an undertaking as either, without its being even heard of. Mr. Gower, mining engineer to the Government, has erected a set of machinery on the island of Sado for crushing and washing the gold quartz, which is found in such abundance there, and it now has been at work for the last few weeks. Sado has been the scene of mining operations for an unknown period, mines being found in different parts of the island, of which no record exists as to when they were worked. Those at present in operation lie on the west side of the island, at a village called Ai-kawa, and here Mr. Gower has erected his machinery. The entrances to the mines are in a valley running up from the village, and they are generally from 150 to 300 ft above the level of the sea, and from 1 to 1¼ mile from it. The new machinery has been erected at the foot of this valley, and from the mines a 2-ft. gauge tramway has been partially constructed, which, when completed, will be an immense saving of labor in the conveyance of the quartz. About ¾ of a mile of the tramway is already finished, and it is calculated that a saving over the whole system of ½ the cost of transport has been effected by it. In this valley alone there are hundreds of mines which have been worked at different periods within the last 200 years, 29 of which are at present in operation; 4,000 miners, crushers, etc., are employed at these, who, with 3,000 fishermen and agricultural laborers, compose the population of the village. The natives, who have been in the habit of crushing the quartz with cast-iron mallets worked by hand, while the grinding washing processes were equally primitive, have succeeded in working 6 to 8 tons of quartz per day, but at a great expense to the Government. The new machinery is capable of turning out 18 to 24 tons per day, its working expenses not being more than $75 for that time. The quartz is said to be very rich, having large quantities of gold, silver and copper in it, but extremely hard, and therefore difficult to work. The machinery is erected in a substantial wooden building, and is driven by an engine of about 20 horse power. The whole process of breaking up the rock, converting it into powder, washing the powder so formed, and separating the gold, silver, and copper, is here carried on. And as parts of the machinery are most unwieldy and heavy, too much credit cannot be given to Mr. Gower, who, with the assistance of a single European, has managed to put them all in their places, and to all appearance in perfect working order.—*Japan Mail.*

AMBER.—A very large proportion of the amber appearing in the various markets of the world is supplied by the province of Prussia, including the neighboring district of Memel. The following particulars are gleaned from a report by Mr. Ward, Her Majesty's Vice-Consul at Memel. In the western portion of the province of Prussia amber is found not only on the seashore, but also in the mountainous ranges of the interior; excepting, however, in rare cases of its appearance in so-called "nests," amber is only to be met with in isolated pieces in the latter localities, so that the profit arising from the amber diggings among the hills is but a very moderate one, and may be estimated at about double the amount paid by the proprietors for the wages of the diggers. In East Prussia, however, and especially in that part called the Samland, amber is more abundant, and during the prevalence of certain winds is frequently thrown upon the shore by the sea in large quantities; it is collected there, as well as fished for in the surf; it is also dug out of the sand hillocks running along the seacoast. In these sand hillocks regular beds of amber are found enclosed in a soil of blue clay, which is to be met with at an average depth of about 100 ft. in a thickness of 25 to 30 ft. It is stated that out of some diggings established in those parts 4,500 lbs. of amber were raised in the course of 4 months of the year 1869. Diggings of this kind exist at present in various spots of the Samland. There are establishments at Brusterort, where amber is obtained by divers from the bottom of the sea, and at Schwarzort, near Memel, where it is raised by dredging for it at the bottom of the Curish Haff. The importance and size of the dredging establishment last mentioned has of late years increased considerably, and at present about 80,000 lbs. of amber are annually obtained by it. The total amount of amber obtained during the year 1869 in all parts of the province of Prussia by the various means of collection is estimated at about 150,000 lbs., the value of which may be taken at 550,000 Prussian dollars. The quantity collected (by fishing for it) in the sea and upon the shore is about equal to that raised by the digging and dredging works. According to the opinion of competent persons, the produce of the diggings could be increased considerably by working them upon a regular mining system. Apart from the fact that no certain knowledge has hitherto been arrived at as to the actual extent of the amber fields in the blue clay,—and these fields exist most probably not only in the vicinity of the seacoast, but also in the interior of the Samland, and even beyond that district and the frontiers of Eastern Prussia,—it is most likely that below the stratum of clay to which the diggings are at present confined there are other strata in which amber would be met with. This supposition is based upon the circumstance that considerable quantities of amber have been found among the soil washed

away by the sea during heavy gales from those portions of the coastal sandhills which lie below the layer of blue clay first alluded to. The prices of the principal kinds of amber, as stated by an official report, vary according to the size, ranging from 22 Prussian dollars per lb., where the pieces run about 9 to the lb., to $1, where the lb. requires 100 pieces or more. The prices of larger (so-called cabinet) pieces are subject to great fluctuations, and are fixed by the increase or decrease of demand from the East; the prices of the commoner kinds seldom vary more than about 10 per cent. The chief seat of the retail amber trade is Dantzic; the wholesale trade is at present in the hands of only 2 or 3 firms in the province of Prussia. The working of the Prussian amber into mouthpieces, beads, etc., is likewise carried on chiefly at Dantzic, but also in all large cities; of late a manufactory of amber wares has been established at Polangen, a small Russian town near Memel, and it is intended to open similar works at Konigsberg, Moscow, and at New York.—*Mining Journal.*

THE UTILIZATION OF WASTE MATERIAL IN MINING.—Immense heaps of refuse or "tailings," as they are technically termed, accumulate where mining operations are carried. These contain a good deal of metal, but no way has yet been devised of extracting it economically. We have improved upon the ancients in that respect, and posterity may improve upon us, as is suggested in the following extract from an Australian journal:—

"In the year 4000, or thereabouts, when the Anglo-Australian race shall have been 'played out' on this continent, and our posterity shall have degenerated as the Greeks have done, will the New Zealander of the period, accomplished in arts which are unknown to us, and armed with scientific appliances such as we have never dreamed of, come over to Victoria and extract tons of gold from the tailings in our desolate and deserted gold fields? The question is suggested by what is actually taking place in Attica. About 300 years before the Christian Era, the silver mines of Laurium were exhausted and abandoned; but 7 years ago a Franco-Italian Company obtained a concession to treat the scoria and other refuse for silver, and their operations have been conducted on so large a scale that a town containing 4,000 inhabitants has sprung up on what was formerly a solitude; a railway has been constructed to the nearest port, and a small steam vessel plies twice a week between Argosteria and the Piræus for the transport of the argentiferous tailings to the roasting furnaces."

NOVEL SURFACE CONDENSER.—We see in an account of a British manufacturing establishment an account of a surface condenser of somewhat notable character.

It is an evoparative surface condenser, in which the condensation of the steam is mainly effected by means of surfaces supplied with a thin stream of water, the actual evaporation of which—and not merely its rise of temperature—effects the condensation of the steam. The steam is exhausted into a narrow annular chamber, or the internal intermediate space between two concentric cylinders, water in thin streams being made to flow down both the outer and the internal surfaces of the annular chamber. Each unit, shown in the sketch of the condenser, thus consists of a pair of thin cast-iron cylinders, the smaller one within the other, leaving such a narrow annular space that the steam offers a considerable surface for its condensation. The joint at the bottom is formed by an annular trough cast on a plate with a central hole, and with lead run in. At the upper end, on the outer cylinder, is cast an internal fillet, fitted against the outer surface of the inner cylinder, and a space is left between the joints for a little water to prevent leakage. An annular trough, open at its bottom, rests on the tops of the cylinders on small ribs connecting its sides. Down the narrow annular spaces water from the pipes above runs in a thin film over both the internal surface of the inner and the external surface of the outer cylinder. The steam to be condensed enters the pipe at the side, and into the annular space, and the water of condensation is exhausted out below by the air-pump. The condensing action of an upward current of air also comes into play, as the condenser is carried by standards so far apart as to leave free access to the inflow up the centre of the annular casing. A number of pairs—four or more—of such units are thus arranged in a row, and constitute a very useful condenser for an ironworks—taking up some room, but, on the other hand, requiring a comparatively smaller quantity of cold water. Several of these condensers are in use at Middlesbrough, England, and have also been adopted for the Lambeth Water-works.—*American Railway Times.*

AMONGST the papers recently read before the Hanoverian Architects and Engineers' Association, and published in the "Zeitschrift des Architecten und Ingenieur-Vereins zu Hannover," vol. xvii., No. 1, we find, at p. 15, one by Professor Ruhlmann, of Hanover, on the history of military breech-loaders, the origin of which he places as far back as the second half of the 15th century. He compares the Prussian needle-gun with the Chassepot, both as regards the weight and dimensions of the arms and the ammunition which they carry, and concludes by recommending the Martini-Henry rifle (already adopted by the Swiss Government) as the best military rifle yet devised.

SELF-ACTING RUDDER.—At the International Exhibition of Naples, a drawing of a self-acting rudder, proposed by Signor M. Siciliano, of Palermo, was exhibited, and attracted great attention as a useful application of electro-magnets. In fact, in the apparatus as described, the movements of the rudder would be entirely controlled by the compass; any deviation in the latter gives a corresponding motion to the rudder which continues until the compass returns to its due position.—*Mechanics' Magazine.*

BURLINGTON, Vt., can boast of the largest planing mill in the world. The lumber yards, docks, sheds, mills, etc., of the firm, cover an area of 50 acres, and in this area there are about 7 miles of plank road. To carry on this establishment from 400 to 500 men and boys are employed.

COAL has been discovered in Rajpore and Kummun, in the territories of the Nizam. Miners have been sent to ascertain the extent of the seam.